THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. IV.

No. XI.—NOVEMBER, 1907.

ORIGINAL ARTICLES.

I.—Notes on Fossil Plants from South Africa.

By A. C. Seward, F.R.S., Professor of Botany, Cambridge.

(PLATES XX AND XXI.)

THE specimens described in these notes form part of a collection sent to me for examination from the South African Museum, Cape Town; they include the following species:—

Phyllotheca Whaitsi, sp. nov. Uitenhage Series[1] (Wealden). Pl. XX, Fig. 1.

Osmundites Kolbei, sp. nov. Uitenhage Series (Wealden). Pls. XX, XXI, Figs. 2–5.

Glossopteris indica, Schimp. = *Rubidgea Mackayi*, Tate. Permo-Carboniferous.

Lepidodendron australe, M'Coy. Lower Karroo (? Lower Carboniferous). Pl. XXI, Figs. 6–8.

Bucklandia sp., cf. *B. anomala*, Carr. Uitenhage Series. Pl. XXI, Fig. 9.

Phyllotheca Whaitsi, sp. nov. (Pl. XX, Fig. 1.)

The specimen represented in Fig. 1 was found by Mr. J. A. Whaits at Prince Albert in shale lying between the Witteberg Series and the Dwyka conglomerate: it consists of a single whorl of leaves of which the longest has a length of 4·5 cm. and a breadth of 3 mm. The linear segments converge towards a narrow axis about 5 mm. in diameter; they show faint indications of a midrib and have acuminate apices.

In spite of the fact that Fig. 1 represents the only example so far discovered I propose, for the sake of convenience, to describe it under a new name, thus placing on record Mr. Whaits's contribution to our knowledge of a flora the discovery of additional records of which would be of exceptional interest. It must, however, be admitted that the specimen for which the generic title *Phyllotheca* is chosen hardly affords satisfactory evidence as to its affinity.

[1] For an account of the Uitenhage flora see Annals South African Museum, vol. iv, 1903.

Osmundites Kolbei, sp. nov. (Pl. XX, Figs. 2–4; Pl. XXI, Figs. 5*a*–*d*.)

The material on which this species is founded was obtained from the Uitenhage Series at Herbertsdale in Cape Colony and presented to the South African Museum by Mr. Kolbe. It consists of several pieces of what appears to have been a large stem reaching a length of about 90 cm. The outline drawing reproduced in Fig. 2 from a photograph sent to me from the Museum by Miss Wilman shows the curious shape of the fossil, tapering to a blunt point at one end and flatter and broader at the other; Figs. 3 and 4 illustrate the surface features as seen on portions of the weathered stem. The smaller piece (Fig. 3) represents the narrow end of the specimen (*x*, Fig. 2); the side seen in the photograph shows the remains of petioles, and on the reverse side numerous sinuous roots occur in association with the bases of leaf-stalks. The roots are approximately circular in section, the portion preserved being the resistant sclerenchymatous sheath which surrounded the central cylinder. Fig. 4 shows a larger portion (33 cm. long) of the stem represented in outline in Fig. 2; the section of the broader end, which is considerably flattened, measures 20 by 6 cm.: at *c* there is a well-marked depression towards which the petioles converge and gradually become smaller in diameter, suggesting the position of a branch apex. On the weathered surface of the block shown in Fig. 4 petiole-bases are seen at various angles and differing therefore in outline: a petiole section exposed at *a*, Fig. 4, and enlarged in Fig. 5*a*, displays the vascular strand of the main axis of the frond as a broad U with the free ends curved inwards; the ridge forming the outer boundary of the petiole no doubt owes its prominence to a band of sclerenchyma which formed a protective and strengthening covering to the leaf-stalk. The form of the vascular strand of a smaller and presumably younger leaf is shown in Fig. 5*b*, and Fig. 5*c* represents a partially crushed petiole (enlarged 3 times) with a flattened U-shaped vascular strand. The petioles exposed at *b*, Fig. 4, are seen more clearly in Fig. 5*d*. There is a close resemblance between this specimen, as regards the structure of the petiole-bases, and *Osmundites Dowkeri*, Carr., from the Lower Eocene of Herne Bay.[1]

The material on which the above description is based is now in the hands of my friend Mr. Kidston, to whom it was sent in the hope that the new species might be more fully described in the monograph on Fossil Osmundaceæ on which he is engaged in collaboration with Mr. Gwynne-Vaughan.[2] Mr. Kidston tells me that a preliminary examination of sections has revealed the presence of tissues in a fairly good state of preservation and confirmed the identification of the stem as a species of *Osmundites*.

In its dimensions and in the branching indicated in Fig. 4 the fossil stem resembles that of the recent species *Todea barbara*, Hook.,[3] an Osmundaceous fern which occurs in South Africa, East Australia, and

[1] Carruthers: Quart. Journ. Geol. Soc., vol. xxvi (1870), p. 349, pl. xxiv.

[2] The first part of this work was published a few months ago by the Royal Society of Edinburgh in vol. xlv of the Transactions.

[3] Seward & Ford: Trans. Linn. Soc., 1904, p. 173.

the North Island of New Zealand. The similarity extends to the form and arrangement of the petioles and their vascular strands. It is noteworthy that with the stem were found imperfectly preserved impressions of *Cladophlebis denticulata* (Brongn.) and *C. Browniana* (Dunk.). I have elsewhere suggested that *C. denticulata*[1] is most probably Osmundaceous, and others[2] have expressed the same opinion. Though we have as yet no satisfactory proof of the correctness of this view it receives some support from the discovery of the stem which it is proposed to name *Osmundites Kolbei*. It is interesting to find that a petrified Osmundaceous stem recently described by Messrs. Kidston and Gwynne-Vaughan as *Osmundites Dunlopi*[3] from Jurassic beds in the Otago district, New Zealand, was also found in association with impressions of *Cladophlebis denticulata*.

"*Rubidgea Mackayi*," Tate [*Glossopteris indica*, Schimp.].

In Tate's paper "On some Secondary Fossils from South Africa" the following passage occurs:—"With the above-mentioned specimens [i.e. *Glossopteris Browniana*, Brongn.] from Bloemkop are some of an apparently, at first sight, second species of *Glossopteris*; these do not exhibit fructification. Dr. Rubidge has, however, communicated a drawing (by Mr. M'Kay) of a specimen of this species obtained by Mr. M'Kay from East London, and I find that it presents characters generically distinct from those of *Glossopteris*; for the position of the fructification is indicated by a few large elevated regions, arising from many veins, and somewhat regularly arranged in a row coincident with the margin, and not by numerous spots, small in size, supported by one vein, distributed over much of the surface of the frond."[4]

The original drawing of the type-specimen of *Rubidgea Mackayi*, reproduced in Tate's paper, is in the Museum of the Geological Society of London, but the actual specimen is not in the collection. The portion of leaf shown in the figure closely resembles a *Glossopteris* frond, except in the absence of lateral anastomoses between the secondary veins; as Mr. Arber[5] points out, it is impossible to determine the plant accurately without seeing the original specimen.

The plants sent to me from the South African Museum for examination include a few impressions collected by M'Kay from East London and labelled by him. On one specimen is written—"A new species of fern named after Dr. Rubidge from G. M'Kay, East London." This is an imperfect impression, 10 cm. long, on black shale of a fairly broad leaf possessing a distinct midrib, from which numerous secondary veins are given off obliquely; lateral anastomoses are frequent and in some parts of the fossil clearly marked. In size and in the course of the veins the specimen agrees with the drawing of *Rubidgea Mackayi* reproduced by Tate. The supposed fructification cannot be recognised, but there are occasional prominences on the

[1] *Ibid.*, p. 253.
[2] Raciborski, "Flora Kopalna": Pamietnika Akad. Umiejetnosci, 1894.
[3] Trans. Roy. Soc. Edinburgh, vol. xlv, pt. 3 (1907), p. 760.
[4] Tate: Quart. Journ. Geol. Soc., vol. xviii (1867), p. 141, pl. v, fig. 8.
[5] Catalogue of the Fossil Plants of the *Glossopteris* Flora, 1905, p. 54.

surface of the shale which bear a remote resemblance to those shown in the drawing. It is possible that the drawing was not intended for an accurate copy of the fossil; it is not improbable, however, that the specimen may be the original of a sketch in which imperfections were partially restored and obscure features freely interpreted. Another specimen collected by M'Kay and bearing his label shows some oval and slightly raised areas which bear a closer resemblance to those represented in the drawing. It is hardly necessary to add, the supposed soral impressions have nothing to do with reproductive structures.

The two specimens referred to (Nos. 19 and 16 in the South African Museum) are imperfectly preserved impressions of *Glossopteris* leaves, and I have no hesitation in identifying *Rubidgea Mackayi*, Tate, with *Glossopteris indica*, Schimp.

Lepidodendron australe, M'Coy. (Pl. XXI, Figs. 6–8.)

The impression of which an outline sketch is reproduced natural size in Fig. 6 was found in black shale brought up from a depth of 344 feet in sinking a bore at Elandsdraai, near Orange River station. The specimen was presented by Mr. F. B. Parkinson to the South African Museum. Mr. Du Toit, of the Geological Survey of Cape Colony, who is familiar with the locality, regards the shale as undoubtedly a member of the Dwyka Series (Lower Karroo). The polygonal areas of which the impression consists are approximately 8–9 mm. long and 7–8 mm. broad at the widest part: they are arranged in regular series. A short distance below the apex of each area there is a more or less circular prominence, showing in some cases a central depression as in Fig. 7. On some of the areas shown in Fig. 6 there are indications of a groove extending from the raised scar to the pointed base, as at *g*, *g*.

An examination under a low magnifying power of the thin layer of graphite which covers the greater part of the fossil reveals the existence of the outlines of parenchymatous cells arranged in fairly regular rows converging upwards from the base and sides of the area towards the raised scar. The cells in the region above the scar do not exhibit the same regularity of arrangement as in the lower two-thirds of the field. The general appearance presented by the cell-impressions is seen in a slightly diagrammatic form in Fig. 7, and a few of the cell-outlines are shown as a camera-lucida drawing in Fig. 8. In examining the graphitic layer I made use of a method recently described by Professor Nathorst[1]: a few drops of collodium were placed on the surface of the fossil, and after a short interval the film was removed and mounted on a slide. The addition of a stain facilitated the microscopic examination and the drawing of the collodium film.

The impression is probably that of a stem of the type known as *Lepidodendron australe*, M'Coy, or *Lepidodendron nathorsti*, Ung., of some authors. The cell-outlines on the surface of the polygonal areas may be those of the epidermal layer, but they were more probably

[1] Arkiv för Botanik (K. Svensk. Vetenskaps Akad. Stockholm), vol. vii, No. 1, 1907; also Geol. Fören. Förhandl., vol. xxix, Häft 4 (1907), p. 221.

formed by a subepidermal tissue; the scar, which interrupts the continuity of the flat surface, may mark the position of a leaf-base, or, assuming a partial decortication to have occurred prior to fossilisation, the scar may represent a gap in the cortical tissue caused by the decay of delicate tissue surrounding the vascular bundle of each leaf in its course through the cortex of the stem. Gaps of this nature are characteristic features in tangential longitudinal sections through the outer cortex of petrified Lepidodendron stems from the English Coal-measures. The indication of grooves seen on some of the areas (Fig. 6, *g*, *g*.) may mark the course of the vascular bundles passing inwards and downwards through the cortex. If the impression (Fig. 6) were that of the actual surface of a Lepidodendron or a Sigillaria stem we should expect to find traces of the parichnos (a strand of tissue which accompanies the leaf-bundle of these plants and forks into two arms just below the base of a leaf, appearing on the leaf-scar as two small scars, one on each side of the scar of the leaf-bundle. In the specimens from Vereeniging described in 1897[1] as *Sigillaria Brardi*, which bear a superficial resemblance to the Elandsdraai fossil, the parichnos is clearly shown. On the other hand, an impression of a partially decorticated Lepidodendroid stem need not necessarily show the parichnos as a distinct feature: owing to its close association with the leaf-trace in the outer cortex, before its separation in the form of two diverging arms, it would not appear as a distinct gap apart from that representing the leaf-bundle.[2] The absence of the parichnos may be regarded as a point in favour of the view that the impression is that of a partially decorticated stem. Similarly, the absence of any demarcation between a leaf-cushion and a true leaf-scar such as characterises the stems of Lepidodendra and many Sigillariæ is also favourable to the same interpretation. The fact that a partially decorticated stem often presents an appearance comparable to that of serially disposed leaf-cushions is in some instances due to the presence of a reticulum of thicker-walled elements in the outer cortex, which divides up the thinner-walled tissue into regular meshes or areas corresponding approximately in shape to the leaf-cushions. It may be that the dark band, *x*, shown in Fig. 7, is the impression of some of the fibres composing a reticulum of strengthening tissue. It is, however, possible that the cells seen in Figs. 7 and 8 may be those of the epidermal layer, and the absence of a parichnos may constitute a definite character, but this is on the whole less likely than the other hypothesis. Although we cannot feel much confidence in the specific determination of stems which have probably lost part of their surface features, we may briefly refer to other specimens which bear a close resemblance to the African fossil.

In 1872 Mr. Carruthers[3] described some Palæozoic impressions from Queensland, some of which appear to be identical with that shown in Fig. 6 under the name *Lepidodendron nothum*, Ung. The material on

[1] Seward: Quart. Journ. Geol. Soc., vol. liii (1907), p. 326, pl. xviii.
[2] For figures of the parichnos strand see Williamson, Phil. Trans. Roy. Soc., 1893.
[3] Carruthers: Quart. Journ. Geol. Soc., vol. xxviii, 1872.

which Unger founded this species[1] was obtained from Thuringian rocks referred to an Upper Devonian horizon; the surface showed the remains of spirally arranged rhombic areas similar to those of the African specimen, and the anatomical structure was compared by Unger with that of *Lepidodendron Harcourtii*. Solms-Laubach,[2] on examining Unger's type-specimen, found that the comparison was based on a misinterpretation, and that the supposed surface-features are those of a partially decorticated stem.

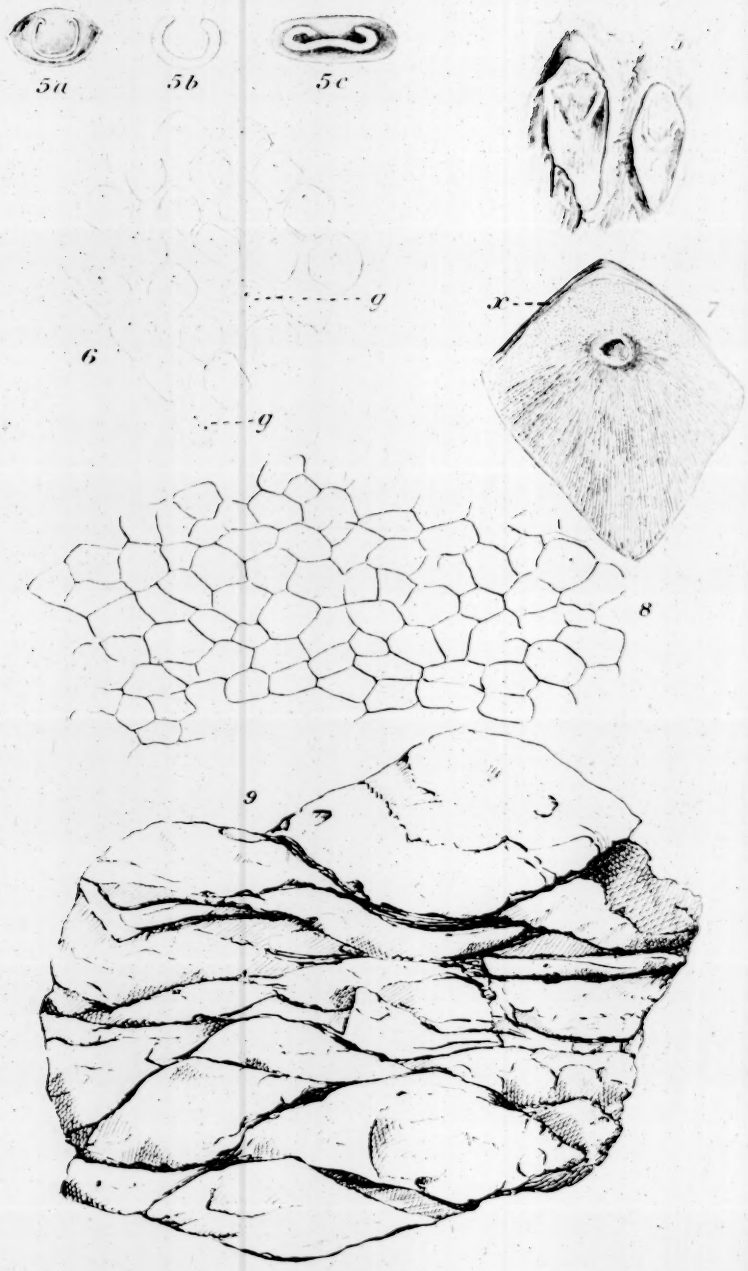
The Queensland fossils are considered by Carruthers, whose opinion is supported by Solms-Laubach,[3] as specifically identical with Dawson's *Leptophlœum rhombicum*.[4]

M'Coy[5] instituted the name *Lepidodendron australe* for some specimens found in rocks of Lower Carboniferous age in Victoria, Australia; the fossils so designated are regarded by many authors as identical with the Queensland specimens of Carruthers. It seems clear that the Queensland and Victoria fossils should be described under the same name, but, as Kidston[6] has pointed out, it is by no means certain that Carruthers was correct in referring his specimens to Unger's species.

An examination of the material described by Carruthers and of the figures published by Feistmantel[7] and other authors leads me to apply M'Coy's specific name to the impression from South Africa. A similar, though probably not an identical, plant has been described by Krasser[8] from China, and from the Devonian of Spitzbergen Nathorst[9] has figured an impression under the name *Bergeria*—a term employed for certain forms of decorticated Lepidodendron stems—which appears to be identical with the Australian type. From the Lower Carboniferous strata of the Argentine Szajnocha[10] describes another example of this form of stem as a Lepidodendron of the *Lepidodendron nothum* group. For a full account of *Lepidodendron australe*, from the point of view of its identity with *Lepidodendron nothum* and as regards its geological range, reference may be made to a paper by Mr. Etheridge,[11] as also to one by Messrs. David & Pittman.[12]

As M'Coy originally pointed out, his species *Lepidodendron australe* agrees closely with a Lepidodendron stem in the Bergeria condition. It may be that the numerous specimens included under his species are impressions of stems which have lost their superficial tissues. Until more is known as to the structure of these plants we cannot be certain as to generic position. Assuming the fossils to be those of

[1] Unger: Denksch. k. Akad. Wiss. Wien, xi (1856), p. 175.
[2] Solms-Laubach: Abh. k. Preuss. geol. Landesanst., Heft xxiii, 1896.
[3] Fossil Botany, 1891, p. 260.
[4] Dawson: Geol. Surv. Canada, 1871, pl. viii.
[5] M'Coy: Prod. Pal. Victoria, dec. i, 1874.
[6] Kidston: Catalogue of the Palæozoic Plants in the British Museum, 1886, p. 231.
[7] Feistmantel: Mem. Geol. Surv. N.S. Wales, Palæont., No. 3 (1890), pl. ii.
[8] Krasser: Denksch. k. Akad. Wiss. Wien, Bd. lxv (1900), pl. ii, fig. 1.
[9] Nathorst: K. Svensk. Vetenskaps Akad. Handl., xxvi, No. 4, pl. ii.
[10] Szajnocha: Sitzber. k. Akad. Wiss. Wien, Bd. C, Abth. i (1891), p. 203.
[11] Etheridge: Rec. Geol. Surv. N.S. Wales, vol. ii, pt. 3.
[12] David & Pittman: *ibid.*, vol. iii, pt. 4.



Fossil Plants from South Africa.

Fig. 5. Osmundites. Figs. 6-8. Lepidodendron. Fig. 9. Bucklandia.

a Lepidodendroid plant—an assumption supported by such evidence as we possess—we are hardly in a position to say that *Lepidodendron* is a more appropriate generic designation than *Sigillaria*. As regards the geological range of *Lepidodendron australe*, it is perhaps more especially characteristic of Lower Carboniferous rocks, though it occurs also in Upper Devonian strata.

Bucklandia sp., cf. *B. anomala* (Stokes & Webb). (Pl. XXI, Fig. 9.)

The specimen represented in Fig. 9 was obtained from the Wood bed of the Uitenhage Series on the Witte River: it is a flattened and somewhat crushed piece of a stem covered with tangentially elongated leaf-bases varying considerably in size. The largest base, shown in the upper part of the Figure, is 2 cm. deep and 3·5 cm. wide; those in the middle of the fragment are much narrower in a vertical direction. It is probable that the striking difference in size, which is much more marked on the side shown in the figure than on the other surface, though partly the result of crushing, may indicate the existence of two kinds of leaves as in recent species of *Cycas* and in the stem figured by Carruthers[1] from the Hastings Sands of Sussex as *Bucklandia Mantellii*, a designation which it has been suggested should be changed to *Bucklandia anomala* (Stokes & Webb).[2] The specimen is worth recording as the first example of a Cycadean stem discovered in the plant-beds of the Uitenhage Series, which have afforded several types of Cycadean fronds.[3]

EXPLANATION OF PLATES XX AND XXI.

Fig. 1. *Phyllotheca Whaitsi*, sp. nov. Slightly reduced.

Figs. 2–5. *Osmundites Kidstoni*, sp. nov.

Fig. 2. Outline drawing showing the shape of the stem. Approximately $\frac{3}{10}$ nat. size.

Fig. 3. Terminal piece of the stem (*c*, Fig. 2).

Fig. 4. Portion of the stem ($\frac{1}{2}$ nat. size) showing petiole-bases and depression (*e*).

Fig. 5*a*. Transverse section of petiole (*a*, Fig. 4).

Fig. 5*b*. Transverse section of vascular strand of younger leaf-stalk.

Fig. 5*c*. Leaf-stalk with crushed vascular band.

Fig. 5*d*. Oblique view of two petiole-bases (*b*, Fig. 4).

Figs. 6–8. *Lepidodendron australe*, M'Coy.

Fig. 6. Nat. size.

Fig. 7. A single area enlarged.

Fig. 8. Cell-outlines (considerably enlarged) as seen on the surface of the area shown in Fig. 7.

Fig. 9. *Bucklandia* sp. $1\frac{1}{2}$ nat. size.

II.—The Tygerberg Anticline.

By Professor Ernst H. L. Schwarz, A.R.C.S., F.G.S.,
Rhodes University College, Grahamstown, South Africa.

(PLATE XXII.)

ROUND the south-western corner of Cape Colony there is a belt of mountains which exhibit a number of exceedingly interesting features. The ranges meet almost in a right angle, the one set

[1] Carruthers: Trans. Linn. Soc., vol. xxvi (1870), pl. liv, fig. 4.

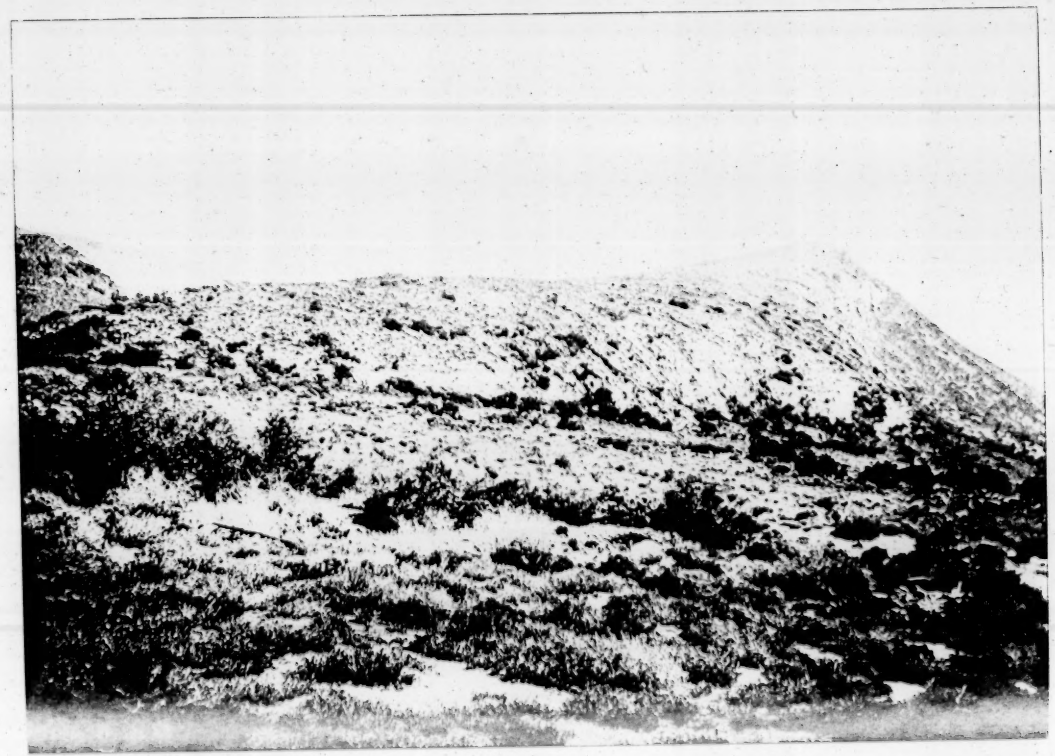
[2] Seward: Catalogue of the Mesozoic Plants in the Department of Geology (British Museum): The Wealden Flora, pt. ii, p. 123.

[3] Seward: Ann. S. African Museum, vol. iv (1903).

trending north and the other east, from a point near Ceres village; this is what Suess calls a 'Schaarung,' and I believe nowhere else in the world does this structure show itself in such a simple manner. Each range is composed essentially of an S-shaped bend, the syncline on the coast side and the anticline on the inner side, while subsidiary folds are added in various places, without, however, obscuring the general nature of the mountain structure. The central axes of the ranges are composed of a coarse grey false-bedded sandstone, the Table Mountain Sandstone resting on the outer side on Pal-Afric beds, slates, phyllites, and intrusive granite, and dipping under later and conformable beds on the inner sides. The age of the Table Mountain Sandstone is uncertain, as, with the exception of indeterminable bivalves found by Griesbach in Natal and possibly a *Patella*, no fossils have been recorded from the series; the overlying beds, however, the Bokkeveld Beds, contain a rich fauna belonging to the American type of Devonian species. On top of the Devonian comes another series of sandstones, the Witteberg Beds, strongly differentiated from the older sandstone series by their yellow and red tints, and the amount of shaly matter intercalated between the sandstone banks. The Witteberg Beds, although strictly conformable to the Bokkeveld Beds, contain a flora which is referable to the Lower Carboniferous, the conformity being supposed to be the result of the ocean floor, during the period occupied elsewhere with the deposition of the Middle and Upper Devonian, having sunk below the area, or rather out of reach of deposition of land detritus. The Witteberg Beds usually form a fronting range of hills separated from the main ranges by a valley occupied with the softer slates and limestones of the Bokkeveld Series. On top of the Witteberg Beds come the series of the Karroo system, commencing with the Dwyka and Ecca; these either form wide flats or a country cut up into small hills or kopjes.

The main ranges thus tower up to 6,000 feet, rarely to 7,000 feet, above plains elevated not more than 1,000 feet, and the abrupt flanks have been carved into tremendous gorges or kloofs by the streams that rush down them when it rains. The axes are usually fairly even as seen against the skyline, but the central ridge is often so narrow that the streams from either side have cut back beyond the watershed and have thus isolated peaks which assume fantastic, pinnacled, and castellated forms. The hill-sides, where not periodically burnt, support a luxuriant heath vegetation, the Ei or Heide veld, consisting of a large number of sugar bushes, *Proteas*, and woody Compositæ, while in among these are the beautiful Cape heaths and everlasting flowers; in two districts there are added the noble Cape cedars, *Callitris juniperoides*, on the north-west, and *C. schwarzi*, which I discovered in the out-of-the-way valleys of Baviaan's Kloof, on the south-east. The wildness and beauty of the mountains have called forth admiration from every European who has climbed among them, and they have been likened from a scenic point of view to the Alps, but from a geological point of view they are entirely different.

The Alps are mountains that have been folded and the folds themselves again folded; in the coast ranges of the Cape the first stage has alone been reached. The difference is that between an



Eastern end of the Tygerberg anticline: the bare dip-slopes of the Witteberg quartzites are seen rising from the plain cut in Dwyka Conglomerate.

anticlinorium and an anticline. And whereas on the Alps the prodigious force has crumpled a whole succession of formations and has allowed recumbent folds to develop, in the coast ranges of the Cape there has been only a single formation folded into the main range, and where an overfold has taken place it is of restricted extent. All the subsidiary folds that develop on the inner or 'stoss' side of our ranges are upright folds, and I wish to lay stress on this point because the large number of papers recently written on recumbent folds in and around the Alps has directed attention to this peculiar feature. Dr. C. Sandberg has ascribed such an origin for the abrupt range of quartzites that rise from the plains north of Prince Albert,[1] in spite of the photograph illustrating the nature of the range which Mr. Rogers published in his "Geology of Cape Colony," p. 141. In the accompanying photograph (Plate XXII) I show the eastern end of the Tygerberg, as this sharp crest is called, where the bare dip-slopes of quartzite are seen rising from out of the plain, composed of Dwyka conglomerate, almost as if they had been made of sheets of some pliable metal like zinc. There are features of interest enough in the Tygerberg without suggesting the additional one of recumbent folds, and however much I should like, for the sake of the interest which such a structure would evoke, that Dr. Sandberg was right, yet if the structure of the coast ranges of Cape Colony is misunderstood, much of the geology of South Africa would become unintelligible.

The difficulty which the Tygerberg presents is that although the quartzites tower up in a narrow vertical anticline, the Dwyka shales and conglomerate around it are only moderately inclined, and indeed in some places lie actually flat. The Dwyka conglomerate is an exceedingly tough, close-grained rock, being in fact a glacial till that has been compressed and hardened by the pressure of some thousands of feet of superincumbent strata now removed by denudation. The Witteberg Beds, on the other hand, show in the extraordinary twists and bends that nearly everywhere characterise the series, that the rock was mobile when deeply buried; the rocks that form the chief bulk of the strata are fine-grained quartzites, and I ascribe this mobility to the fact that silica at temperatures and pressures found in the earth's crust at a depth of a couple of miles is easily soluble. What has happened, then, in the Tygerberg, is that an earth-fold has developed with an east and west trend; the Dwyka conglomerate has yielded but slightly to the folding, but the underlying quartzites were reduced to such a state that they were ready to flow in any direction where there was relief of pressure, the process being one of solution and redeposition of the substance of the individual grains. Eventually the folding became so great that the Dwyka conglomerate had to yield, but instead of bending, a vast rent developed through the strata down to the underlying quartzites. This gave relief of pressure, and the quartzites came squeezing through the gap in the overlying beds much in the same manner that lead may be made to flow between the jaws of a vice. The process in the case of the Tygerberg was

[1] Trans. Geol. Soc. South Africa, vol. ix (1906), p. 82; *Nature*, August 22nd, 1907, p. 423.

naturally an exceedingly slow one and was accomplished at considerable depth beneath the earth's surface; the flow of quartzite can only take place at certain temperatures and pressures, and directly these fall below a certain point, solution and redeposition of the substance of the constituent grains cease, and the rock becomes the hard, brittle, intractable rock one is familiar with.

If I am wrong in my explanation of the causes which led to the formation of the Tygerberg anticline, I am quite sure that my description of the effects produced is correct; I visited the hill many years ago before I had studied the main ranges to the south, but could make nothing of the difficulties, although I had Sawyer's map and sections[1] with me and found them correct; it was only later that I began to see the nature of the fold after spending a considerable time at the place.

Turning to the larger mass of Witteberg Beds to the south which form the range of hills fronting the Swartebergen, the beds are perfectly exposed in the many kloofs, while there is very little vegetation to obscure the details. One can trace each individual stratum, and the whole series is accounted for; there is no break in the succession whence the root of the supposed overfold could have originated. The same is true of the main range of the Swartebergen, for it is just in this longitude that there is the magnificent gorge, called Meiring's Poort, where the structure of the mountain strata is so clearly revealed that there is no possibility of the existence of a great limb missing. Contrariwise, on either end of the Tygerberg the Dwyka and Ecca Beds are folded in a gentle anticline continuing that of the quartzite.

III.—Inclusions in some Volcanic Rocks.

By J. Allan Thomson, B.A., B.Sc., F.G.S.

My attention was first drawn to this subject by the study of a remarkable crystal breccia, occurring at Kakanui, New Zealand, of which a description is given below. The only similar phenomena I could read of in the Colonial libraries at my disposal were those of the diamond pipes at Kimberley, described by Professors Carvill-Lewis, T. G. Bonney, and Miss Raisin in this Magazine.[2] Having since had the opportunity, thanks to the hospitality of Professor Lacroix, of studying in his laboratory at Paris, I found that the proper discussion of this subject comes under the study of the inclusions of volcanic rocks, of which he has given so admirable an account in his book "Les Enclaves des Roches volcaniques."[3] At his recommendation I collected some inclusions from the well-known

[1] A. R. Sawyer, Report on the Geology and Mineral Resources of Prince Albert; Parliamentary Report, Cape Town, 1895.

[2] Numerous scattered references to crystal tuffs occur in British petrological literature, and the subject is well presented by Sir A. Geikie in "The Ancient Volcanoes of Great Britain," especially vol. i, p. 62, and vol. ii, p. 79, but the general paucity of information on this point in the standard textbooks is remarkable.

[3] A. Lacroix: "Les Enclaves des Roches volcaniques"; Macon, 1893.

dolerite of Portrush, and studied them under his guidance. The present paper consists of a discussion of rocks from these two localities, with descriptive notes on a few other inclusions that I have in my collection.

Two things stand out clearly from a cursory examination of this book, the frequency, almost the universality, of inclusions in igneous rocks, and the importance of the aid which they afford to the student of volcanic phenomena. Under these circumstances, it is remarkable how long this branch of study has escaped attention from British geologists. Lacroix's useful nomenclature has not been adopted in our literature, although Phillips, Teall, Sollas, Harker, Judd,[1] and others have paid considerable attention to some varieties of inclusion, and Harker has established a slightly different classification of these phenomena.

Before proceeding to actual descriptions it will be of advantage to outline Lacroix's terminology and most important conclusions, and to correlate the terms already in use. Lacroix establishes two classes:—

A. *Enclaves enallogènes.*
B. *Enclaves homœogènes.*[2]

A.—The first, *enallogenous inclusions*, are without any genetic relation to their host, but are merely accidental inclusions of rocks which the magma has been able to pick up in its progress to the surface.

B.—The second class, *homœogenous inclusions*, are not mere accidents, but are considered to be related to their host in that they have crystallized from the same magma in depth. The best known type are the olivine nodules of basaltic rocks.

Zirkel, following Sauer, uses the terms *Einschlüsse exogene* in the sense of Lacroix's *enclaves homœogènes*, and insists on the difference between such inclusions and the basic secretions (*Schlieren*) of granitic rocks.[3] Doelter makes a similar division into *exogene* and *endogene*, correlating these with Lacroix's *enallogène* and *homœogène*.[4] But in many recent descriptions German authors have preferred the latter terms.

In English scientific literature the term *xenolith* has practically established itself in the sense of an enallogenous inclusion. It was proposed by Sollas in his paper on the rocks of Carlingford,[5] while individual crystals derived from foreign sources were called *xenocrysts* to distinguish them from phenocrysts.

Harker, in a paper on mixed rocks,[6] and in his memoir on the Skye rocks,[7] distinguishes *accidental* and *cognate* xenoliths. In the latter "there is a genetic relationship between the enclosed and the

[1] For a discussion of the subject in 1893 and previous literature see Judd, Q.J.G.S., vol. xlix (1893), p. 175.

[2] Ἕτερος = different; ὅμοιος = similar; γενάω = to beget.

[3] F. Zirkel: "Lehrbuch der Petrographie," 2nd ed. (1893), vol. i. p. 794.

[4] C. Doelter: "Petrogenesis," 1906, ch. vii, p. 101.

[5] Trans. Roy. Ir. Acad., vol. xxx (1894), p. 495.

[6] A. Harker, "Igneous Rock Series and Mixed Igneous Rocks": Journal of Geology, Chicago, 1900, p. 589.

[7] A. Harker, "The Tertiary Igneous Rocks of Skye": Geol. Surv. Mem., 1904, p. 351.

enclosing rocks, and here the xenoliths have probably a deeper significance." For scattered crystals of foreign origin he uses the term *sporadic xenocrysts*. This 'genetic relationship' of cognate xenoliths to their host is not to be confused with that of homœogenous inclusions. They are to be understood as fragments of rocks already consolidated which belong to the same petrographical province. Thus the inclusions of gabbro in granite in Skye are considered cognate xenoliths. Lacroix regularly includes such cases amongst the enallogenous inclusions.

Judd, in describing the *glomeroporphyritic* structure of the Fair Head dolerite, says[1]: "Those who regard the enclosures composed of olivine, enstatite, augite, etc., which are found in some basalts as having separated at some period from the magma, out of which the surrounding rock was itself formed, may regard these as examples of the glomeroporphyritic structure on a gigantic scale." Conversely, we may regard the small groups of anorthite and olivine crystals, with the structure of troctolite, which lie scattered through the dolerite, as homœogenous inclusions of small dimensions.

Throughout this paper, then, I shall speak of inclusions as enallogenous or homœogenous, dividing the former into xenocrysts and cognate or accidental xenoliths.

The study of xenoliths is important because of the alterations that they have undergone under the influence of the enclosing magma. In other words, they furnish the best materials for the study of the contact metamorphism, both exogenous and endogenous, of volcanic rocks.[2] It is rare to find strongly marked contact phenomena at the junction of volcanic rocks with older rocks, but even where this is the case, as with the Portrush rock described below, the inclusions generally show the same phenomena more strongly marked and more easily studied. Lacroix has found from the study of these inclusions that a broad division of volcanic rocks must be made into the two classes *trachytoid* and *basaltoid*. The former contain orthoclase or acid triclinic felspars, the latter are without these minerals. This division is set up because in the former the modifications undergone by the inclusions are often intense, are of a chemical order, and can only be explained by the presence of *mineralisators*, while in the latter the metamorphic phenomena are less intense and could be produced by the action of heat alone, or, if of a chemical order, are limited to the surface of the inclusions.

The absence of mineralisators in basaltoid lavas is to be explained by their more complete fluidity, permitting of the escape of the gases. That mineralisators are present with the magmas in depth has been shown by Lacroix in his study of the ophites and lherzolites of the Pyrenees.[3] The trachytoid lavas, on the other hand, being much more

[1] Q.J.G.S., vol. xlii (1886), p. 71.

[2] Lacroix has summed up his conclusions on this subject in a paper "Etude sur le Métamorphisme de Contact des Roches Volcaniques": Mémoires présentés par divers savants à l'Académie des Sciences, tome xxxi (1894), No. 7.

[3] See A. Lacroix, "Les Phénomènes de contact de la Lherzolite et de quelques Ophites des Pyrénées": Bull. Carte Géologique de la France, No. 42 (tome vi, 1895), ch. iii, p. 124.

viscous and cooling more slowly, have not had their gases disengaged so fast, so that these have had time to act chemically on the inclusions and to determine the formation of many minerals—mica, orthoclase, etc.—that cannot be reproduced artificially by pure fusion alone.

It is noteworthy that this division of volcanic rocks corresponds with that established by the work of Fouqué and Levy on the synthesis of igneous rocks. The basaltoid rocks can all be reproduced by fusion and suitable re-cooling, the trachytoid cannot.

The study of homœogenous inclusions is of interest because of the light they throw on the relations between volcanic and plutonic rocks. The inclusions may be divided into two classes, those which possess the same mineral assemblage and practically the same chemical composition as their host, and those which are formed only of the large minerals of the intratelluric crystallisation and are more basic. The former kind are called by Lacroix the *formes grenues* or granular form of the eruptive rock, the second *enclaves basiques* or basic inclusions. As examples of the first may be cited biotite sanidinites in biotite trachyte, and nepheline syenite in phonolites. Sometimes instead of the plutonic rock corresponding to the volcanic host there are found rocks which otherwise occur in association with the former; e.g., camptonites, which so often accompany nepheline syenites, are found in the phonolites of Mont Dore. As examples of the basic inclusions, the olivine nodules of basalts may be taken. The generalisation may be made that in trachytoid rock the 'formes grenues' of the host are more frequent and the basic inclusions rare, whilst in basaltic rocks the reverse is the case. For a discussion of the mode of origin of homœogenous inclusions reference must be made to Lacroix's book. He admits that here similar phenomena may be arrived at in different ways.

The following descriptions are all of inclusions in basaltoid rocks:—

I. Inclusions of the Dolerite Sill of Portrush, Co. Antrim, Ireland.

This rock is so well known and has been so often noticed that a description of it would be out of place here. Sir A. Geikie[1] has remarked the fine grain assumed by the otherwise coarsely crystalline dolerite near its junction with the Lias shales, and Professor Cole has given a description of the microscopic structure of both types in his suggestive account of the contact phenomena.[2] The inclusions examined by me are all from the coast section, and include holocrystalline nodules from the coarse dolerite at the north end of the cape and inclusions of dolerite and Lias from the east side near the junction. Sir A. Geikie mentions the difficulty of distinguishing the basalt and the Lias rocks at the contact; this difficulty is accentuated with regard to the inclusions, for in these the shale has assumed a more crystalline appearance, and inclusions of a flinty type of igneous rock in the dolerite show a great resemblance to sedimentary rocks.

[1] Loc. cit., vol. ii, p. 209.

[2] G. A. J. Cole, "On Contact-Phenomena at the Junction of Lias and Dolerite at Portrush": Proc. Roy. Ir. Acad., vol. xxvi, sect. B, No. 6, p. 62.

A. Exallogenous Inclusions.

1. *Cognate Xenoliths.*

Cognate xenoliths have already been noted by Professor Cole in dolerite veins cutting the olivine dolerite.[1] They consist of "the compacter and basaltic layer" which the veins have entered. Those collected by me may be of this category, though I did not observe that the including rock was a vein. They are of a fine dolerite in a coarse one. They are of a grey flinty appearance with frequent crystals of pyrites, and are irregularly mottled with dull greenish patches.

In thin sections they are seen to consist of an aggregate of small felspars, generally in short stout prisms, but often rounded, with patches of irregularly-shaped augite grains, which extinguish simultaneously; it is an ophitic structure in which the optical continuity remains, but the actual continuity of the augite (in section, at least) is broken. It is these plates of augite which give the hand-specimens the mottled appearance. The felspars run from labradorite to anorthite, and preponderate largely over the augite. Olivine is absent. The rock is thus a fine-grained ophitic dolerite. It has suffered no great change from its reheating.

2. *Accidental Xenoliths.*

The alteration of the Lias at its contact by the intrusive dolerite (here basaltic) has been fully described by Professor Cole in the paper already referred to. But near the shore contact it is not uncommon to find patches of the Lias included in the basalt, and where this is the case the contact phenomena are much more marked. Professor Lacroix has observed[2] that along the shore the Lias has been changed to a rock formed mainly of cordierite and extremely rich in crystallites of pyroxene and a little magnetite, with here and there small grains of quartz intact. This alteration is somewhat different to that described by Professor Cole, who has found no cordierite. According to my specimens, the Lias some little distance from the contact contains a good deal of quartz and magnetite and some pyrite in elongated patches, around which is recrystallised quartz, a few scattered flakes of biotite, some chlorite, numerous small granules with a high index which seem to be pyroxene, and a few colourless crystals which may be cordierite; but the fineness of grain and the overlapping of the individual crystals makes identification of all the constituents difficult. A few inches from the actual contact the rock is still fine-grained, but the granules of pyroxene are more recognisable. The rock also contains patches of colourless minerals of larger size, most of which are felspars with Carlsbad twins, but occasionally albite twinning also occurs and anorthite can be recognised. Round the borders of the patches the pyroxene granules are more closely studded and of slightly larger size. Rarely a pleochroic mineral occurs in the patches. From its very great relief and the strength of the birefringence it agrees with staurolite rather

[1] Loc. cit., p. 63.

[2] "Les Enclaves des Roches volcaniques," p. 655.

than with andalusite, which Professor Cole has found in the contact zone.

It is only among the actual inclusions that I have found specimens similar to those described by Professor Lacroix. The presence of cordierite in minute crystals is difficult to verify microscopically unless basal sections are found giving the characteristic twins. In none of my sections can these be found, but they resemble so much Professor Lacroix's sections, which he kindly lent me for examination and in which he was able to obtain this verification, that I do not hesitate to identify as such a mineral occurring abundantly in roughly quadrate plates with straight extinction compared to the direction of elongation. It has in general a lower interference colour than the quartz which is also present, and it is crowded with inclusions of magnetite and fine granules of pyroxene.

Another type of inclusion is quite different from any rock hitherto described from this locality. The hand-specimens differ from the altered Lias only in the presence of streaks of a dull greenish-white colour. In thin sections the darker part is seen to consist of granules of a green pyroxene, much larger than those in the contact specimens, interspaced by colourless prisms and grains of a felspar which occasionally includes the pyroxene. The lighter-coloured streaks are formed, some of felspar with subsidiary wollastonite, some of felspar lime-garnet and calcite, with scattered grains of the green pyroxene. This latter mineral shows an occasional cleavage trace and is faintly pleochroic. Extinction angles up to 42° ($\mathfrak{c} \wedge \mathfrak{C}$) on longitudinal cleavages have been observed. The pleochroism in thick sections is: $\mathfrak{a}$=pale grass green, $\mathfrak{b}$=yellow green, $\mathfrak{c}$=blue green. The felspar is most easily determined in the colourless patches, where it is of largest size. The extinction angles with reference to the trace of the plane of symmetry of the albite twins show it to be anorthite. The lime garnet is confined to a few of the streaks. It occurs in irregularly rounded grains. The wollastonite has a habit not unlike anorthite, from which it may be distinguished by its slightly higher refringence, and by the variable sign of the elongation of its sections; those giving positive elongation, and under convergent light an optic axial cross perpendicular to the elongation, may with certainty be referred to wollastonite. It does not occur in great quantity. The rock therefore consists largely of lime silicates and was probably a calcareous band in the Lias.

The study of these inclusions is thus seen to give valuable aid in the study of the contact phenomena of this rock. Professor Cole suspected wollastonite,[1] but was unable to verify its presence, nor were the colourless granules of sufficient dimensions to furnish him means of determining the felspar. The development of cordierite in the argillaceous inclusions of basaltoid rocks is mentioned by Lacroix as very frequent.[2] In the case of the Portrush rock he considers it "little doubtful that a part of the elements necessary to its formation are of exogenous origin."[3] Limestone inclusions are generally simply

[1] Loc. cit., p. 59.

[2] Loc. cit., p. 49.

[3] "Etude sur le Métamorphisme de Contact des Roches Volcaniques," p. 47.

calcined, but when silicates are developed they are almost always wollastonite, augite, and garnet.[1] The phenomena exhibited by the inclusions of the Portrush rock are then in complete conformity with the phenomena described by Lacroix.

B. Homœogenous Inclusions of the Coarse Dolerite.

These are rounded nodules about an inch and a half in diameter, and can be seen microscopically to consist of augite, felspar, and olivine. Microscopic examination shows that they are holocrystalline with typical ophitic structure, the felspar being idiomorphic towards the olivine as well as towards the augite. The olivine percentage varies, and in the more basic types greatly exceeds that of the augite. The felspar is always abundant and consists of a basic labradorite. Magnetite is the only common accessory. It occurs in one slide in large idiomorphic crystals.

These inclusions do not differ either in mineral composition or in structure from the rocks that enclose them, but they are still more coarsely grained. They are normal ophitic dolerites. They probably represent secretions of the magma at a slightly greater depth, but under almost the same conditions of cooling as the sill.

Professor Cole makes an interesting suggestion with regard to the possibilities of modification of the main mass of the dolerite. While he has identified andesine as the felspar, along the east shore the felspar seems to be always labradorite or anorthite. Clearly, as he says, "there is room for further research in this well-visited and attractive field."

II. Inclusions of the Kakanui 'Mineral Breccia.'

This rock occurs on the sea-coast near the township of Kakanui, Otago, New Zealand. Its general characters and position in the stratified series have been described in a former paper.[2] It is a calcareous stratified breccia of Oligocene age, and contains a remarkable variety of crystalline volcanic products, as has already been noted by Mantell.[3] There is no massive rock in the district that can be directly connected with it, although basaltic puys are abundant in the district, but it contains a few blocks of basaltic rocks which may be assumed to represent the lava-form of the magma by the explosion of which the breccia was formed. Enallogenous inclusions of gneiss, mica-schists, grauwacke, and limestones are not rare, but have not been studied. The chief interest lies in the size and the variety of the minerals, causing a great resemblance to the tuff necks of the Fife coast and to the diamond pipes of Kimberley, and in the nature of the homœogenous inclusions.

The basaltic fragments are not fresh enough to ensure a good determination of the rock, but the two types may be recognised. Both contain pseudomorphs of red rimmed serpentine after phenocrysts of

[1] "Les Enclaves des Roches volcaniques," p. 141.

[2] J. A. Thomson, "The Gem Gravels of Kakanui": Trans. New Zealand Institute, vol. xxxviii (1905), p. 481.

[3] Q.J.G.S., vol. vi (1850), p. 324.

olivine. The augite is fresher and is a pale variety, but is in part replaced by chlorite. A little brown hornblende is present. Calcite is abundant and apparently fills vesicles. The groundmass in both cases is very dark with ferruginous decomposition products. In the first type, a little altered plagioclase felspar is present; the groundmass is more glassy and contains small granules of augite and olivine. The rock has been an olivine basalt. In the other the felspar is absent and the augite in the groundmass is elongated into prisms. The rock appears to have been a limburgite. The character of the homœogenous inclusions strengthens the supposition that the magma has been an ultra-basic one. All the other basalts recorded in the district contain felspars, and in none are the inclusions similar.

The hornblende is generally without any corrosion border, but occasionally well-rounded crystals are found including large crystals of magnetite. It is probably to this corrosion that the polished and rounded surfaces of the hornblende crystals in the tuffs are due. In one slide a large crystal of augite also showed corrosion phenomena.

Homœogenous Inclusions.

1. *Isolated Crystals.*

Numerous minerals occur in isolated fragments in the tuffs and breccia, and sometimes attain a tremendous size, especially felspar, hornblende, and a black augite. Garnets, a green augite, biotite, and olivine occur in smaller fragments. The hornblende, garnet, and black augite are sometimes beautifully polished and rounded. With the exception of the felspar these minerals can all be traced to the inclusions described below. Its origin has remained an enigma. It occurs in all sizes up to 70 mm., elongated in the direction of the two principal cleavage faces. Crystal faces are wanting. It is transparent and colourless except where the cleavage planes are coated with calcite, in thin sections perfectly clear and free from inclusions. It is twinned according to both the albite and pericline laws, and the extinction angles and a partial analysis show it to be an acid oligoclase.

2. *Holocrystalline Rocks.*

These occur in great abundance. The commonest type, in fragments with diameters up to eight inches, is an olivine nodule containing much calcite. The more compact types are smaller, and contain olivine only in subsidiary amount. A totally distinct type consists primarily of a black augite and garnet. All these rocks are holocrystalline and granular with fairly coarse texture. None of the elements have crystalline forms, but the spinels and the hornblende which they contain are posterior to the other minerals. They may be conveniently divided into three groups, these being characterised by the presence of spinel and a green augite (diopside or diallage) in the first, a black augite in the second, and predominant basaltic hornblende in the third. The following table will show the different mineral combinations:—

Mineral combinations of Kakanui inclusions.	*Analogies amongst homœogenous inclusions.*	*Analogies amongst plutonic rocks.*
A. (1) Spinel, green augite, olivine ...	Olivine nodules.	Lherzolite.
(2) Spinel, green augite, olivine, brown hornblende	Hornblendic olivine nodules.	Hornblende lherzolite.
(3) Spinel, green augite, olivine, brown hornblende, garnet		Hornblende eulysite.
(4) Spinel, green augite	Pyroxene nodules.	Ariègite.
(5) Spinel, green augite, garnet		Garnet ariègite.
B. Black augite, garnet, with or without hornblende and magnetite	New type of pyroxene nodules.	Basic ariègite.
C. Hornblende, subsidiary garnet, and biotite	Hornblende nodules.	Hornblendite and hornblende ariègite.

The types grouped under A differ from ordinary olivine nodules in the absence of enstatite and the comparative rarity of olivine. Lacroix, however, notes[1] that besides normal olivine nodules there exist more basic types characterised by the presence of brown basaltic hornblende, which moulds all the other elements, and that these are sometimes poor in enstatite and even in olivine and picotite, while the chrome-diopside is replaced by augite. The presence of garnet has not, so far as I can find, been noted in olivine nodules. The green augite resembles the chrome-diopside of lherzolite in colour and in microscopic appearance, but it presents at times an incipient diallage structure. The spinel is generally a green pleonaste, more rarely a brown picotite. This mineral is stated in textbooks to be without cleavage, but in one section a beautiful cubic cleavage may be observed. The garnet is of the pale-rose colour seen in the garnet ariègite of the Pyrenees.

The types grouped under B differ from any well-known plutonic rock or inclusion of volcanic rock. It is still open to question whether they are really homœogenous inclusions, but I incline to this view because of the presence of brown basaltic hornblende and the general similarity of all these rocks to the basic rocks accompanying lherzolite in the Pyrenees. The augite has in hand-specimens a bottle-glass appearance with conchoidal fracture and a jet-black colour, translucent on thin edges. In thin sections it has a pale bistre colour, almost without pleochroism, and a fair cleavage, on which extinction angles up to 41° have been observed. It contains as inclusions regularly arranged rows of rounded or elliptical grains of iron ores, sometimes black and opaque, sometimes translucent and reddish, crossing the cleavage at a considerable angle. The garnet is of a red-brown colour, and is evidently different from that occurring in the types under A.

The commonest type of the rock consists only of the augite and garnet in thoroughly allotriomorphic forms. The augite sometimes includes the garnet, and *vice versâ*. With the incoming and predominance of brown hornblende, which moulds the augite, the rock passes over to the next type.

[1] Loc. cit., p. 486.

Under type C may be grouped all the stages from large crystals of brown hornblende, containing subsidiary inclusions of garnet and biotite, down to the types under B, where hornblende is an accessory mineral.

Another rare type of rock in the breccia seemed to consist of kernels of altered olivine nodules cemented by hornblende and biotite. No material fresh enough for microscopic study could be obtained.

The similarity of olivine nodules to lherzolites has long been known. Lacroix regards them as having been formed by segregation in depth in the basalt magma, forming a crust on the walls of the reservoir that has been broken through on eruption. Although their chemical composition is more basic than that of the basalt which encloses them, and the whole magma could not have crystallised out as lherzolite, yet a considerable mass of the rock might conceivably be formed. In a rock so little felspathic as the Kakanui basalt one is not surprised by their abundance, while the similarity of the other types to the basic rocks found in association with lherzolite is only what might be expected. It will be of interest to demonstrate this similarity.

In his study of the basic rocks accompanying the lherzolites and ophites of the Pyrenees,[1] Lacroix describes two series of rocks: the first, which he has named *ariègites*, always occur associated with the lherzolites; the second, various hornblende rocks, occur as veins in the lherzolite, or in separate bosses. Lherzolite is not always a homogeneous massive rock, but is often banded, at the Etang de Lherz for instance, one band being formed of normal lherzolite, the other of ariègite. It is distinguished from lherzolite by the absence of olivine and enstatite, and consists in the normal type of a monoclinic augite and abundant spinel, while subsidiary types are formed by the presence of garnet and basaltic hornblende. The structure is sometimes like that of lherzolite, sometimes kelyphitic.

The inclusions grouped under A above will be readily seen to resemble in all respects lherzolites and ariègites. It should be remembered that the lherzolite at Lherz contains hornblende.

Under the name of garnetiferous hornblende ariègite is described a rock consisting of brown hornblende, some flakes of mica, and large grains of red garnet with a little magnetite and spinel. The general resemblance of the types placed under C to this rock is sufficiently evident.

The second series of rocks accompanying the lherzolite is very varied, but is characterised by the presence of brown basaltic hornblende as an essential mineral. Among these rocks are hornblendites, pyroxene hornblendites, and hornblende peridotites. The extreme types of inclusion under C may be called hornblendites.

In none of these Pyrenean rocks is there any augite that at all resembles that in the B type of inclusions. The extraordinary colour is probably due to a high percentage of titanium. The rocks do not probably differ much in chemical composition from garnetiferous ariègites.

[1] Comptes Rendus viii International Geological Congress, 1900, p. 806.

The inclusion of isolated minerals in tuffs and volcanic necks has puzzled many students of volcanic phenomena. In the first place their origin is obscure, as often they cannot be traced to any known rocks; and in the second place, even if they are known in the associated igneous rocks, their size is still a puzzle. Sir A. Geikie says:[1] "The crystals in question seem, however, to point to some chemical process still unknown, which, in the depths of a volcanic focus, under conditions of pressure and temperature which we may speculate about but can perhaps hardly ever imitate in our laboratories, leads to the elaboration of the diamond, garnet, sahlite, smaragdite, zircon, and other minerals." The case of the Kakanui breccia shows at least that the majority of these minerals so often found in tuffs, including the refractory garnet, do form in homœogenous nodules from the volcanic magma. One may even speculate that the origin of the minerals of the Kimberley diamond pipes is due to the same process, and that the associated rocks may be in large part of the nature of homœogenous inclusions.

Homœogenous Inclusion in Greenstone Sill, Cudden Point, Cornwall.

In his discussion of inclusions Lacroix has wisely confined himself almost entirely to the younger volcanic rocks in order to eliminate all phenomena due to later alteration. Now that his conclusions are well established it is of interest to study those of the older volcanics as well. The West Cornish greenstones are very free from inclusions, if we except veining from the granite contacts, but in that of Cudden Point I have found large blocks of homœogenous inclusions. The sill itself has been profoundly affected by pressure and secondary changes, and near its lower boundary consists practically of a schist formed of fibrous hornblende and zoisite, but the original rock was probably an ophitic dolerite. The inclusions have suffered also from these changes, but not nearly to the same extent. They have, as it were, formed eyes (*Augen*) during the production of the schist. They still contain the original augite, ophitically enclosing large plates of plagioclase felspar, which is the predominant element of the rock. In the absence of Carlsbad twins Levy's exact method is not available, while the largest angles of extinction observed on symmetrically lying albite-lamellæ amount to 12°. This would indicate a basic oligoclase, but it is unlikely that the felspar is so acid. One or two of the crystals show a slight zonary banding.

The effects of crushing are seen in the bending of the lamellæ of the felspars and local comminution with production of a granulitic structure. One augite crystal is neatly faulted.

Secondary changes are the production of numerous granules of zoisite in the felspars, and in the growth of a colourless fibrous hornblende from the augite along its boundaries and in its cleavage cracks. Small fibres exist also in the felspars.

[1] Loc. cit., vol. i, p. 62.

IV.—Notes on some Coastal Features in Co. Waterford.

II. Woodstown to Passage East.

By F. R. Cowper Reed, M.A., F.G.S., etc.

On a previous occasion (Geol. Mag., Dec. V, Vol. IV, 1907, pp. 17–20) an account was given by the author of Fornaght Strand in the estuary of the River Suir; and the nature and development of the drift deposits further up the river may now be described.

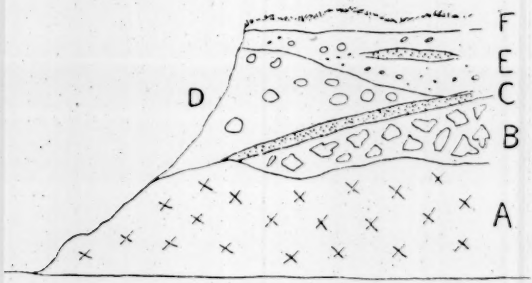
On the north side of Knockavelish Head (which bounds Fornaght Strand on the north), the coast from Ballyglan is bordered by low sand dunes for a distance of about a mile and a half, and there is no cliff or exposure of any solid rock, the old sea margin being apparently situated now some way inland behind an area of more or less marshy land at the back of the dunes. Traces of the former sea-cliff can, however, be recognised here and there by a sudden slight rise in the ground. A wide flat expanse of sand and mud, known as Woodstown Strand, is uncovered at low tide along this stretch of coast, extending out fully a mile from high-water mark, but so far no trace of the submerged forest of Fornaght has been here discovered.

At the north end of the sand dunes a low cliff of drift commences, and increases gradually in height till it ends against the igneous rocks of Newtown Head in the interesting section given on p. 502. This drift cliff for its whole length to this point is composed of the ordinary Boulder-clay of the district, capped by a bed of sandy yellowish or whitish marl, 1–1½ feet thick, free from included boulders, but not otherwise sharply marked off from the underlying Boulder-clay. Towards the southern end of this line of cliffs, the section is capped by a bed of recent drifted sand, 6 inches to 1 foot thick, passing up imperceptibly into the subsoil and soil, which is mixed with a little vegetable matter. Occasionally short bands or isolated patches of cockle-shells of fairly recent appearance occur in this bed at varying depths below the present surface of the ground. These accumulations of shells must be regarded as due to human agency, though probably of an early date.

At Newtown Head itself, the cliff is 20–25 feet high, and the clayey bed on the top of the Boulder-clay is here replaced by a mass of clayey angular gravel or rubble devoid of bedding, but in places showing small lenses and bands of grey or yellow sand (E). The rock-fragments composing it are of various sizes, and not sorted or rounded, but angular, and of local origin. Probably we may regard this deposit as representing the Upper Head, washed and redeposited by running water. Below this comes the Boulder-clay proper (D), with a thickness of about 12 feet, but it wedges out rapidly against the upward sloping surface of the underlying beds. There seems to be a greater number of included boulders in its upper part (though none are of large size), as if the clayey matrix had been to some extent washed out and carried away.

Immediately beneath the Boulder-clay is a thin but fairly continuous bed of light-coloured sand, varying from 2 inches to 1 foot in

thickness (C), and dipping down seawards at an angle of about 20°, roughly parallel to the eroded surface of the solid rock on which the whole series of drift deposits rests. This sandy bed cannot be regarded as equivalent to the 'Blown-sand' of the Cork district described by Messrs. Wright & Muff, for the latter occurs beneath the Lower Head, while at Newtown Head it rests upon the Lower Head (B). It must be regarded as marking a local episode on a sandy shore before the deposition of the Boulder-clay (D). The true Lower Head of Newtown Head occurs immediately beneath this layer of sand, and is composed of large angular fragments of the solid 'greenstone' on which it reposes, imbedded in a very scanty sandy matrix. The blocks are quite irregular in size and arrangement, and are all angular and usually large, measuring up to one foot or more in length, but in one spot the fragments are of a smaller and more uniform size and show rough bedding. This mass of Head (B) rests on an uneven hummocky but rounded surface of 'greenstone' (A), and measures about 6 feet thick at its maximum, being banked up against the old pre-glacial sloping cliff and spread over the irregular rock-platform. In this instructive section at this point the Lower Head is seen to thin out rapidly to the east, so that the Boulder-clay overlaps it and comes to rest directly on the solid greenstone.



Section of Cliff at Newtown Head.

A. Solid greenstone with eroded upper surface.
B. Coarse angular head, composed of unworn fragments of the underlying rock in scanty sandy matrix. ± 6 feet thick.
C. Light-coloured sand. 2 inches to 1 foot thick.
D. Boulder-clay, more stony at top, up to 12 feet thick.
E. Sandy and clayey angular gravel, occasionally bedded with some lenses of pure sand; rests on irregular surface of Boulder-clay. 1½ to 4 feet thick.
F. Surface soil.

On the north side of the headland the present cliff face is chiefly of solid rock and is much obscured by vegetation. Coarse angular rubble-drift may be seen in places near the top of the cliffs resting on the Ordovician rocks, and the subsoil frequently contains a layer of cockle-shells. The Boulder-clay reappears in about 300 yards at the top of the cliff, and rapidly increases in thickness northwards by descending to the present beach-level or nearly so, being as much as 20 feet thick and forming practically the entire face of the cliff all the way to Raheen Stream. A layer of sandy clay or marl containing

few or no stones overlies it with a thickness of 1–1½ feet, as on the south side of the headland. At the spot where the fossiliferous Raheen Shales are exposed on the foreshore the recent removal of shingle and slipped material from the base of the cliffs which has been obscured in former years has exposed in section the pre-glacial platform and the deposits immediately overlying it. This platform is cut across the edges of the steeply-inclined Ordovician beds elsewhere described, and its surface forms a fairly regular and horizontal line in the face of the cliff about 3 feet above its base. The height of this rock-platform above the present high-water mark seems only 3–4 feet, and its upper 1–1½ feet is somewhat shattered and rotten, though the line of demarcation from the drift deposits is always sharp and clear. In one place a small stream running down to the present seashore has cut a narrow gully through the Boulder-clay, but its vertical corrosion has been stopped by the pre-glacial platform so that it falls over its eroded edge in the cliff in a small waterfall.

There is a layer of angular débris here and there resting on the platform, composed of small angular fragments of the underlying rock, but in several places bedded sandy fine shingle or sand with larger well-rolled beach pebbles in it is found to a thickness of 2 feet. The Boulder-clay rests directly on it, and contains near its base a few large rounded or subangular boulders (some as much as 3 feet in diameter) of the local Old Red Sandstone or local igneous rocks, but no true Lower Head. Probably the absence of the Lower Head may be explained by the fact that the pre-glacial cliff lies now some distance inland and that the Head did not extend far out from its foot, while here we are dealing with the more seaward portion of the platform. In most cases the Boulder-clay rests here immediately on the solid rock without any intervening deposit. The activity of post-glacial coastal erosion at this point and the non-resistant character of the rocks are illustrated by the solid rock of the old pre-glacial platform being cut back as rapidly as the drift cliffs, so that they are both exposed in section in one and the same vertical face. But where the rocks are of a tougher nature traces of the old platform extend over the foreshore as irregular ridges and reefs of rock.

On the north side of Raheen stream, which has cut down right through the platform to the present sea-level, there is an excellent exposure of the platform, for it forms a flat-topped shelf several yards wide jutting out on the foreshore at the base of the present cliffs of drift, and has not been so much eroded or dissected as a little further south. It is here cut across the edges of the nearly vertical slates and flags, almost at right angles to their strike, and its level surface has 2–3 feet of coarse angular débris (Lower Head) of the same rocks resting upon it and capped by the usual Boulder-clay. About half-way between the gap at Raheen Bridge and the gully of Carey's Stream we find a true beach deposit on the platform in the shape of well-rounded pebbles cemented together in a little coarse sand. The Boulder-clay reposing directly on these deposits is of a reddish colour and marly character, and contains few stones; it averages 2–3 feet in thickness, but generally it passes up into the normal type of Boulder-clay except from the spot where this beach deposit occurs.

At this point the reddish clay is succeeded by a sharply marked off band of greyish clay 1½–2 feet thick, characterised by containing numerous angular fragments of black or greenish slate, mostly small, but scarcely any fragments of Old Red Sandstone. Northwards this slaty deposit assumes a definitely bedded character with a sandy or marly matrix, at the same time increasing in thickness till about half-way between Raheen and the Cable Station it is quite 5 feet thick, with the upper part composed of rather large angular fragments 4–8 inches long of banded purple and green slates lying flat and horizontal with little finer matrix between them, the lower portion, however, still consisting of smaller and more scattered chips of slate in bedded sandy clay. Boulder-clay, 1–2 feet thick, of somewhat variable character, lies beneath it, resting directly on the platform without the intervention of any true 'head,' but here and there a thin black layer, 2–3 inches thick, full of small rounded pebbles and angular chips of slate cemented together, adheres to the platform, and seems to be a local modification of Messrs. Wright & Muff's 'ferricrete.' The bedded slaty deposit thins out before we reach the Cable Station, and the Boulder-clay forms the whole cliff 30–40 feet high. Thin bands of reddish or ochreous clay 2–4 inches thick can here and there be distinguished near the base of the cliffs in the Boulder-clay, but only persist for a few yards. The rubble drift on the top of the cliffs is usually thin, but rests on a somewhat irregular surface of Boulder-clay. Landslips and vegetation much obscure the section beyond the Cable Station, but the cliffs steadily decrease in height, owing to the reduction in thickness of the Boulder-clay, and below Crooke Chapel they are only 6–8 feet high. About 100 yards north of Crooke the solid rock of the old platform appears on the beach close under the low cliffs, being disclosed in patches between the shingle; it consists of greenish-grey and sea-green shales, slates and flags in thin alternating layers; soft purple shales and fine-grained purple flags are intercalated a little further north in beds ½ inch to 3 inches thick, alternating with the greenish beds. These all dip regularly at 80° in a general northerly direction or are vertical. The Boulder-clay apparently rests directly on this platform, but the latter soon is lost to sight, and our interest is concentrated on the cliffs, which begin to increase in height, and in which the Boulder-clay, capped by about 2 feet of rubble drift and subsoil, is remarkable for the large number of huge boulders imbedded in it. Many of these are of non-local rocks (granites, quartzites, etc.), and these are more or less rounded and reach a size of as much as 2½–4 feet in length. The masses of the Old Red Sandstone breccia are angular and even larger in size.

A most varied series of the non-local rocks can be easily collected out of the Boulder-clay here, and the beach is strewn with similar boulders of all sizes derived from the cliffs. About nine-tenths of the larger blocks are of the local Old Red Sandstone beds, but examples of the Ordovician rocks, igneous and sedimentary, of co. Waterford itself (i.e. of the country to the west) are remarkably rare.

A few blocks of the felsites and other igneous rocks (especially the nodular perlitic felsite of Raheen gap) have been drifted up-stream from Newtown Head, but only occur on the beach and not in the

Boulder-clay; moreover, their unworn condition generally enables them to be easily recognised.

Of the non-local sedimentary rocks the commonest are white, grey, or yellowish fine-grained quartzites occurring as well-rolled and rounded boulders up to a foot in diameter. Some coarser-grained quartzose grits may also be occasionally found.

Blocks of Carboniferous Limestone in a well-rounded condition are frequent; they are usually of a dark bituminous variety, and often contain fossils (*Lithostrotion*, *Productus*, etc.), and some of these boulders measure two feet in length. A pale-grey crinoidal limestone from the Carboniferous Series is sometimes found. Pieces of chert are rare, and no flints such as Messrs. Wright and Muff have described on the Wexford coast have been observed.

Of the non-local igneous rocks a rather coarse-grained but non-porphyritic grey granite occurs rather plentifully in much rounded boulders and subangular blocks of all sizes, and it seems identical with the Mt. Leinster granite. Boulders of pink granite of two or three varieties are much less common. A greyish granophyre or micro-granite is as abundant as the grey granite; and likewise blocks of a diorite, several gabbros, coarse porphyritic diabases, aplites, quartzose schists, schistose felsites, gneisses, augen-gneisses, vein-quartz, vein-breccias, etc., may be extracted out of the cliffs in a more or less worn and rounded condition.

The derivation of this varied assortment of non-local rocks from the area to the north (Wexford, Kilkenny, Wicklow, etc.) cannot be doubted, and the Boulder-clay which contains them must be regarded as the deposit of the inland ice[1] and not of that from the west or the Irish Sea.

At a point about 500 yards south of Passage East, where the cliffs of drift reach a height of 30–40 feet, we notice coming in at their base beneath the Boulder-clay a more or less bedded deposit of angular slabs, flakes, and chips, of the slates, shales, and flags of the pre-glacial platform which was exposed on the foreshore nearer Crooke. The fragments are sorted into fairly uniform sizes, 2–4 inches in length, and lie flat and closely packed without much intervening finer material. The deposit rapidly increases in thickness as we follow it northwards in the cliffs. The base of it becomes much coarser, the fragments being 1 to 2 feet long, but still lying flat and horizontal, and all consisting of ragged angular slabs of the slates, etc. A few small rolled pebbles of Old Red Sandstone may be found in this Lower Head, but they are very rare. The upper part of the deposit, on the other hand, becomes composed of minute flakes and chips of soft Old Red purplish shales aggregated into a loose crumbling and unconsolidated mass of material, without any appearance of bedding and extremely apt to slip down on account of its incoherent character. Near the base of the coarse slaty head at the foot of the cliffs there is a layer, 4 inches to 6 inches thick, of similar angular fragments cemented together into 'ferricrete' by infiltrating water with iron oxides, and it can be traced horizontally for over 50 yards. An interesting section is seen

[1] Wright & Muff, Scient. Proc. Roy. Dublin Soc., vol. x, part 2 (1904), p. 269.

here in the cliffs where a landslip has recently occurred. The coarse angular head of slate fragments, 4–5 feet thick, lies at the base; it passes up gradually by diminution in the size of the rubble into the fine crumbling incoherent deposit of flakes of shale, which is 12–15 feet thick; above this comes 6 feet of Boulder-clay, containing many large boulders; and resting on this are 3½–6 feet of false-bedded gravel, pebbly sand, and lenses of pure sand. This deposit above the Boulder-clay was evidently laid down by water; the pebbles are small and well rolled, and large pebbles are very rare. Subsoil and soil, to a thickness of 1–1½ feet, lie on the top of all.

The basement bed of coarse head contains more and more frequent fragments of the Old Red Sandstone rocks as we approach Passage; the slates become an insignificant element and ultimately disappear, the head then consisting of small angular and subangular fragments of the local Old Red beds, mostly 1–4 inches in size, with very little clayey matrix and with occasional huge ragged blocks of the Old Red breccia. These masses become more common and the head still much coarser till the finer material practically disappears, and great irregular jagged blocks of the breccia, some 5 feet in length, are jumbled together into a deposit of 8–9 feet thick, on which the Boulder-clay reposes. The foreshore is strewn with big boulders and angular masses derived from the cliffs. The platform of greenish and purple slates, etc., on which the drift rests is visible here and there on the beach, but not above the present high-water mark.

The actual pre-glacial cliff is not exposed, and the section ends abruptly with the termination of the drift cliff and with the beginning of the sea wall and embankment along the south side of the low flat area on which Passage village is chiefly built at the bend of the river.

The hill which rises 250 feet above the village is mainly composed of the coarse Old Red breccia, which enters so largely into the composition of the Lower Head at the northern end of the section, and the older slates, etc., on which the Old Red rests with such a striking unconformity form the lowest slopes and base of the hill, and have furnished the material for the other type of head.

V.—The Inclination of Overfolds in Relation to the Larger Folds in which they are contained.

By George Hickling, B.Sc.,
Assistant Lecturer in Geology in the Victoria University of Manchester.

WHILE spending a few days recently examining the sections on the North Devon coast, with a view to obtaining a clearer conception of the tectonic structure of that region, I was deeply impressed by the great number of minor overfolds and with the great uncertainty in the relations of the various beds thereby brought about. In many cases where the dip appears to be constantly to the south, through a considerable thickness of strata, closer examination shows repeated isoclinal folds. The western face of Little Hangman Hill at Combe Martin exhibits such a condition very well. Throughout the

whole coast which I examined, from Combe Martin to the southernmost part of Bideford Bay, the axes of the minor folds are inclined to the north in this way, so as to frequently produce the appearance of steady southern dip and greatly to increase the apparent thickness of the strata. In speculating as to the possible cause of the constant direction in which the axes of these folds are inclined, an explanation occurred to me which I believe to be the correct one, and which may be applied generally to a large number of cases. As I have been unable to find it in the works I have been able to consult, it may be desirable to publish it, since it may aid considerably the elucidation of the true structure and history of complicated districts.

The one feature in the structure of Devon which admits of no dispute is the broad syncline which comprises the whole county. On this broad fold those previously referred to are superadded, and from the parallelism of the two, and the fact that they were both formed after the Culm and before the Permian, it is almost certain that their formation proceeded *pari passu*. How, then, would the form of the minor folds be affected by the fact that the whole area was at the same time becoming a syncline? It is obvious that in a synclinal fold the upper beds tend to be compressed, the lower ones to be extended. Both of these effects are resisted, and the result is a sliding of the beds relatively to one another on the sides of the fold. This may be illustrated admirably by an experiment described by Mellard Reade in his "Origin of Mountain Ranges" (p. 210 and pl. xlii). A number of strips of paper are laid horizontally, and their edges marked across with vertical lines thus:—

Fig. 1.—Edge-view of pile of paper strips, with lines drawn across at right angles to the plane of the papers. (After Mellard Reade.)

If the paper is now forced into folds, the displacement of the various layers relatively to one another is shown by the fact that the vertical lines are no longer vertical to the surface of the paper, thus:—

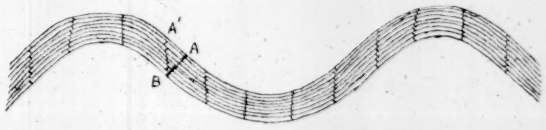


Fig. 2.—The same papers folded, showing displacement of lines. (Modified after Mellard Reade.)

The line starting at B, for example, instead of passing at right angles to the plane of the strips towards A, is displaced to A'. Now, if these vertical lines be assumed to represent the axial planes of minor folds, it is clear that those folds will become asymmetrical, their crests being forced outwards from the centre of the syncline. In a shallow syncline the displacement of these axes would only be slight, but, however slight, it would still exist, and would determine that the

folds would be asymmetrical, with their steep sides facing away from the main synclinal axis, on either side, as indicated in the subjoined diagram.[1]

FIG. 3.—Showing the distortion of minor folds by the relative displacement of the layers in the larger one.

Let us now assume the lateral compression of the whole area to continue. What will be the result? Either the general syncline may become deeper, or the minor folds may be accentuated. But, since the extent to which a great fold can be raised or depressed is limited, the latter result will sooner or later occur, and as the minor folds are accentuated they will become overfolds, tending more and more to be isoclinal as they are further compressed. It is important to notice that *the limbs of such isoclinal folds will dip towards the axis of the major syncline, on either side.* Here, I believe, we have the true explanation of the character of the folds seen so admirably on the North Devon coast.

It is scarcely necessary to add that what has just been said of minor folds on synclines will apply equally, with suitable modifications, to minor folds on anticlines. In the latter case there will tend to be produced more or less isoclinal folds with limbs dipping away from the main anticlinal axis. Hence we may conclude as an important general rule that *the direction of dip of the limbs of a series of isoclinal folds indicates the direction of dip of the side of a larger fold on which they have been produced.* By this means, the former existence of a great fold may be inferred when the structure of a district has become so complicated that direct evidence of it is obscured or lost.

For example, if in a great syncline a series of minor overfolds are produced on either side as here described, and the crushing still continues, it is evident that the sides of the syncline will gradually be pushed in under the central portion, and fan-structure will be the result. And thus it would seem highly probable that areas presenting fan-structure, notwithstanding the fact that they present the general features of an anticline, and have, indeed, been aptly described as anticlinorums, have originated by the modification of great synclines. As my friend, Mr. D. M. S. Watson, suggested to me, an analogous process may help in some degree to explain why hills have so frequently a synclinal structure.

Further, it needs little consideration to show that the direction of overthrusts will be governed by the same rule that holds for overfolds.

[1] This modification of the minor folds may be beautifully demonstrated by taking a pile of sheets of paper laid flat, drawing symmetrical curves on the edges, and then folding the paper. If the paper is folded sufficiently, beautiful isoclinal curves may be produced.

since the latter pass into the former. Hence, if a pair of overthrusts dip towards one another, it is highly probable that the area they enclose was primarily a syncline, or, on the other hand, if they dip away from one another, an anticline. Thus, from the direction of the two great series of thrust-planes which form the north-western and south-eastern boundaries of the Grampians it seems probable that that region began its tectonic history as a syncline, while the central lowlands, on the other hand, would seem to have been a corresponding anticline.

It will be observed that the Central Lowlands now form a broad syncline. But that is just what should be expected. From a consideration of what has already been said it should be clear that the original folds tend to become virtually reversed, the axes of the synclines raised, and the summits of the anticlines depressed.

No doubt, from the premises that the form of a minor fold is influenced by the side-shift of superposed beds caused by the formation of a larger fold in which it is contained, many more interesting deductions might be drawn, but enough has, I think, been said to illustrate the nature and general effect of that influence. That the relation here stated is the only cause of the deformation of minor folds I would not wish in any way to suggest. The series of strains and stresses set up in the terrestrial crust must be more complex than we can ever hope to completely disentangle. But I do maintain that we have here a distinct set of effects which can be separately recognised and traced to a definite cause. That other influences must give rise to irregularities is inevitable. Yet I think an appeal to the rocks shows that there is still, in many cases at least, a distinctly recognisable residue of effects which may be traced to this one cause, by the observation and consideration of which much help may be derived in the elucidation of the tectonic history of complex districts.

NOTICES OF MEMOIRS.

I.—Index Generum et Specierum Animalium.[1]

THE indexing of the literature for the second portion of this Index (1801–1850) has steadily progressed. Among the works included are:—Archiv für Bergbau, etc., 43 vols.; Archiv für die gesammte Naturlehre, 27 vols.; Archiv für Naturgeschichte, 16 vols.; Athenæum, 23 vols.; Basel, Naturforschende Gesellschaft, 8 vols.; Batavia, Batav. Genootsch., 16 vols.; Beiträge zur Petrefactenkunde (Muensters); Berlin, Gesellschaft naturforschende Freunde; Berlin, Bericht und

[1] Report of the Committee, consisting of Dr. Henry Woodward (Chairman), Dr. F. A. Bather (Secretary), Dr. P. L. Sclater, Rev. T. R. R. Stebbing, Dr. W. E. Hoyle, Hon. Walter Rothschild, and Lord Walsingham. By C. Davies Sherborn, F.G.S., F.Z.S. Read before Section D (Zoology), British Association, Leicester, 1907.

Abhandlung k. pr. Akad. Wiss., 50 vols.; as also the writings of Audouin, Audebert, Audubon, Audinet, and Bechstein, a list which might be considerably extended.

The accumulated results of three years recording have now all been arranged and sorted under their respective genera, and, therefore, one set of entries is now available for reference by monographers so far as recording has proceeded. The duplicate set of entries has been partially arranged and further accommodation has been provided by the kindness of Dr. Smith Woodward in the Geological Department of the British Museum (Natural History), which has greatly relieved the pressure arising from the steady growth of material.

II.—Investigation of the Pre-Devonian Beds of the Mendips.[1]

THE principal objects which the Committee had in view were two in number—(1) To obtain a further series of fossils from the newly discovered Silurian beds of the area. (2) To investigate the distribution in the field of a peculiar coarse ashy conglomerate, and to ascertain its relations to the other deposits of the neighbourhood. With these ends in view a series of seven trenches was dug, and the information obtained from them was incorporated in a paper by the Secretary.[2]

The most easterly of these trenches was dug in a field about 300 yards S.S.W. of Tadhill Farm. It was carried to a depth of about six feet, and after passing through some 18 inches of surface material, entered a deposit consisting mainly of very fine yellow and brown ash, with subordinate bands of coarse ash. Many of the bands were crowded with fossils, which were identified by Mr. F. R. C. Reed.[3] The series of fossils, though undoubtedly Silurian, and, in Mr. Reed's opinion, probably of Upper Llandovery age, was insufficient to determine the point with certainty.

A second trench dug at a point about 100 yards to the north of that in the fossiliferous tuff proved to be in trap (pyroxene andesite).

The remaining five trenches were all dug in the neighbourhood of the rifle butts on Beacon Hill (about a quarter of a mile to the north of Beacon Farm), where the coarse ashy conglomerate was originally exposed in a target pit. Four trenches dug at different points in the neighbourhood of the rifle butts showed that the coarse ashy conglomerate here probably occupies the whole area between the northern and southern outcrops of the Old Red Sandstone. A fifth trench was opened on the slope of the hill to the north of the rifle butts, but after passing through nine feet of Old Red Sandstone this trench was abandoned.

[1] Report of the Committee, consisting of Mr. H. B. Woodward (Chairman), Professor C. Lloyd Morgan, the Rev. H. H. Winwood, and Professor S. H. Reynolds (Secretary). (Drawn up by the Secretary.) Read before Section C (Geology), British Association, Leicester, 1907.

[2] Published in the Quart. Journ. Geol. Soc., vol. lxiii (1907), pp. 217–238.

[3] See list, op. cit., pp. 226–227.

III.—Desert Conditions and the Origin of the British Trias.[1]

By J. Lomas, A.R.C.S., F.G.S.

IT is now generally conceded that the Triassic rocks of our Islands are not of marine origin, but true continental deposits, and the view has of late gathered strength that the climate was arid when they were laid down. We can only hope to reach a safe conclusion by a critical examination of existing deserts. Let us confine ourselves to a consideration of the activities now at work in some typical sandy deserts, such as we suppose to have existed in Triassic times.

Sandy Deserts.

Rainfall.—As a rule sandy deserts are characterised by a low rainfall, and their distribution is in general either on the leeward sides of mountain ranges or in valleys and plateaux between such ranges. In Northern Egypt the precipitation ranges from 0·27 inch at Cairo, to 1·1 in. at Suez, 2·1 in. at Ismailia, 3·4 in. at Port Said, and 8·1 in. at Alexandria. In South California and West Arizona certain regions have a mean annual rainfall of less than 2 inches. In the Karoo the precipitation varies from 8·65 inches at Steotleville to 18·76 in. at Graaff-Reinet (Buchan). In the Kalahari desert from 3·79 in. at Pella to 41·10 in. at Pilgrims Rest. On the west coast of Africa from 2·11 in. at Port Nolloth to 8·37 in. at Clan William.

Examples need not be multiplied; those quoted are sufficient to show that the amount is generally small and varies very considerably in different places. An equally important consideration is the *time* during which rain falls. If the precipitation is confined to one season and for the rest of the year there is little or no rain, desert conditions may exist, although the annual rainfall is comparatively large. During the wet season the ground may be well watered, and streams of torrential size flow over the country, but the water is soon lost by percolation or evaporation and none is stored up to water the land in time of drought.

Vegetation is either very scant or absent, and the lack of vegetable mould diminishes the power of the soil to retain moisture. Professor N. S. Shaler (U.S. Geol. Surv. 12th Report) points out too that the absence of vegetable mould commonly causes the soil to present a dense baked surface which sheds rain like a roof.

Streams of Desert Regions.—In South Africa during the dry season we often come across deep watercourses excavated during the time of the seasonal rains but now perfectly dry. Their beds are covered with well-rounded boulders of such a size as to indicate that torrents must have flowed down the courses in order to move them. Towards the mountains the banks become steeper and loftier, while in the direction of the plain the valley merges into the general outlines of the veldt, and at the junction it is marked by a spread of pebbles. In the Libyan and Algerian deserts similar watercourses are found in the neighbourhood of their enclosing mountains. They are liable

[1] Proc. Liverpool Geol. Soc., vol. x, pt. 3, 1907, pp. 172–180; slightly abridged.

to floods of so sudden appearance and of such torrential violence that people engaged in gathering firewood, brought down by former floods, are sometimes overtaken and have no chance of escape. At one time the bed may be perfectly dry and a moment later it is filled with a rapid stream hundreds of feet wide. In India these sudden floods are sometimes miles in width; they have no defined channel, but flow like a sheet over the land.

It is worth while at this stage to picture what kinds of deposits are being formed under the conditions just described. While the main portion will be composed of sand there will be included at various horizons patches of gravel, lenticular in shape and of limited extent. I have seen sections through such deposits in a dry donga near Tintas Kopje in the Vryheid district, and again in railway cuttings when traversing the Eastern desert of Egypt between Ismailia and Cairo. The pebble bands varied from a few inches to 4 or 5 feet in thickness, and in my notebook is an entry "exactly like our Bunter." However, we shall return to that later. I only wish at present to record the impression made on me at the time.

What becomes of the water?—The water flowing over the sand may be disposed of in three ways. (1) It may percolate under the surface; (2) it may be evaporated; (3) it may lodge in pools or lakes in places which are below the general level of the country.

(1) *Percolation.*—It has been known for a long time that under the dry baked sands of the desert there commonly exists a great store of water, which only needs to be tapped in order to be available for use. In the Sahara artesian wells were sunk by the Greeks and Romans. In Algeria a class of men called Meallem were formerly employed as water-finders, and another class—the R'tassin—were engaged in the construction and cleaning out of wells. Their methods were primitive and involved great dangers. Since the French occupation more scientific appliances have been introduced, and the fringe of fertile soil on the margin of the great Sahara is gradually being extended southwards. In sinking the dry sand is penetrated until an impermeable clay or pan is reached. On piercing this the water rises, sometimes with sufficient force to reach the surface. The depth of the impermeable layer varies from a few feet to hundreds of feet, and striking differences of level may be encountered within a short distance.

The condition of the water below the impervious bands must necessarily be largely a matter of inference. We naturally want to know whether it is stagnant or flowing, and whether it is carrying substances in solution and depositing these round the sand grains and thus cementing them into compact rock. If the water is flowing it must trend towards an outflow, and if this is restricted in area there must be definite lines along which the water runs. The stream lines will, under these circumstances, be convergent towards the outfall, and the water outside the cone of flowing water may be stagnant.

That subterranean streams of fresh water do flow into the Red Sea from the desert is certain, and opposite their mouths the coral growth round the coast is interrupted. Some of these streams have been traced underground for great distances almost to the base of the

Abyssinian mountains. The wells in the oases, too, must be fed from the same source.

Similar lines of flow of percolating water can be traced in our local Triassic rocks. Sometimes they show themselves by a deeper staining, and in extreme cases the grains of sand have become so heavily charged with interstitial matter that they have formed pipes, the interior of which is dark brown or even black, while the sand surrounding is almost white.

(2) *Evaporation.*—Another way in which the water flowing from the high grounds is disposed of is by evaporation. The amount of evaporation is largely dependent on the relative humidity of the air. Over the oceans the air may be approximately saturated, but in deserts the amount is commonly as low as 20 per cent. of the total capacity of the air to hold moisture. At Assuan it is 38 per cent. for the year, varying from 29 per cent. in Summer to 51 per cent. in Winter. At Wadi Halfa the average for the year is 32 per cent.

When the air is not saturated, there is a constant exchange of water from the land to the atmosphere, and this results in evaporation at the surface and a creep of water from below owing to capillary action. Mineral substances contained in solution are disengaged from the water on evaporation at the surface, and the soils in course of time become charged with saline matter. In this way the 'sour' or 'alkaline' soils have their origin.

The nature of the encrustation will, of course, depend on the composition and the amount of salts which the water holds in solution, and these again are dependent on the nature of the rocks over which the water passes. Potash and soda salts are common encrustations in some regions, and they are often associated with the carbonates and sulphates of the alkaline earths. The former may be redissolved and partly removed in the rainy season, but the salts of the alkaline earths will be effected only to a very slight extent and will tend to accumulate. A very instructive example of this occurs in the dry donga near Vryheid mentioned above. Near the surface the sands are coated with carbonate of lime. Sometimes there appear embedded in the sand roundish balls, ranging from the size of a marble to that of a man's head. In other places limestone of a compact texture and not enclosing sand forms a continuous layer on the surface of the ground.

At Croft, near Leicester, a calcareous crust exactly resembling that found in deserts occurs on the surface of the underlying igneous rock, and the covering Keuper marls are strongly impregnated with lime salts.

(3) *Desert Pools and Lakes.* — Looking across a vast expanse of desert the monotony of the scene tends to dwarf the sense of vertical height. With no outstanding features to rivet the attention of the eye the rolling dunes or naked rock give the impression of a level landscape. As a matter of fact the desert has its hills and its hollows, its crags and its ravines. In some of these hollows, enclosed in a network of dunes or in rocky basins, water tends to accumulate and form pools or lakes. They may be fed by rain, by water percolating through the surface sand, or by streams flowing from the hills.

Often they have no outlet, and then the water can only be lost by evaporation. They are full to overflowing when the seasonal rains fall, but during the long drought the waters gradually diminish, and in many instances totally disappear.

The water which finds its way into these pools or lakes brings with it matter in suspension and in solution. The former settles at the bottom as a fine mud. The mud, on drying, shrinks and forms the triradiate cracks characteristic of contracting sheets; it receives the imprints of animals' feet when they come to drink, and the impressions of rain when it falls.

The mud from the margin of a partially dried up vley at Riverton in South Africa shows all these features, and in addition it contains vast quantities of the carapaces of *Estheria*, a tiny Crustacean which has its proper habitat in such surroundings.[1]

The matter brought into the pools in solution will tend to concentrate as the water diminishes, and on complete drying, deposits of salt, gypsum and other salts will be left behind.

The salinity of the water will vary with the season. Thus, pools in the Rajputana desert in India are fresh for two or three months in the year. One constantly comes across contradictory statements in reading books of travel as to the salinity or otherwise of certain lakes. The observations may be right in each case if the travellers visited the lakes at different seasons of the year.

(*To be concluded in our next Number.*)

REVIEWS.

Memoirs of the Geological Survey.

I.—The Geology of the South Wales Coalfield. Part VII: The Country around Ammanford. By Dr. A. Strahan, F.R.S., T. C. Cantrill, B.Sc., E. E. L. Dixon, B.Sc., and H. H. Thomas, B.Sc. Text, pp. 246, with 12 illustrations, price 2*s.* 6*d.* Colour-printed maps, Sheet 230, Drift and Solid, 1*s.* 6*d.* each.

Part VIII: The Country around Swansea. By Dr. A. Strahan, with parts by R. H. Tiddeman, M.A., Dr. W. Gibson, and E. E. L. Dixon, B.Sc. Text, pp. 170, with 4 illustrations and 5 plates, price 2*s.* 6*d.* Colour-printed maps, Sheet 247, Drift and Solid, 1*s.* 6*d.* each.

WITH the publication of these Memoirs and that of Part IX (West Gower) already noticed in the Geological Magazine (August, 1907, p. 371) we witness the completion of the survey of the main portions of the great South Wales Coalfield, and Dr. Strahan is to be congratulated on the progress thus made in a task in which he has taken the prominent part and has personally superintended.

[1] "Habitat of *Estheria*": Trias Report, British Association, 1905; and Monog. Pal. Soc., 1862, p. 57.

The area of Coal-measures included in the maps before us and described in these Memoirs was originally surveyed by Sir William E. Logan; and the results of his labours were generously placed at the service of De la Beche, who surveyed portions of the Lower Carboniferous rocks and Old Red Sandstone. Aid was also received from John Phillips among the Lower Palæozoic rocks.

The results of the recent survey on the six-inch scale show a great advance in methods and details, in the determination of the numerous lines of fault, and in the mapping of the superficial deposits. These advances are shown perhaps more conspicuously in the Ammanford area, where Cambrian (Tremadoc) rocks have been recognized, while no less than eight subdivisions, together with limestone bands, are represented in the Ordovician rocks, five subdivisions are shown in the Silurian, six in the Old Red Sandstone, and many in the Carboniferous rocks. In this great series of formations it is estimated that the thickness of strata amounts to nearly five miles. We have been a little puzzled to find Ammanford on the map, but have succeeded in doing so with the aid of a gazetteer wherein Ammanford is mentioned as a hamlet with "coal-mines, also paint and oilworks." As a matter of fact, there is no town of note in the area, and the population is somewhat scattered along the principal valleys, such as the Tawe between Ystradgynlais and Pontardawe.

Mr. Cantrill and Mr. Thomas have largely added to our knowledge of the stratigraphy and palæontology of the Lower Palæozoic rocks. The Llandeilo Series is described with the spelling Llandilo "for the sake of conformity with the New Series Ordnance Maps," a change which hardly makes for uniformity, as it is inconsistent with the generally accepted spelling of geologists.

A table and local lists of Lower Palæozoic fossils are given, and a method has been devised whereby the precise locality, the collector, and the destination of every specimen have been recorded. It must be admitted that these important particulars are not of much value in the memoir, except when it is used in the Museum at Jermyn Street, where are preserved the specimens and also the six-inch maps on which the localities are indicated.

Interesting accounts are given of the changes in the lithology of the Old Red Sandstone and of the overstep of its basal portions across the Silurian outcrop. The dominant features in the region are great plateaus formed by the Millstone Grit, which rises in Black Mountain to a height of 2,076 feet, and by the Pennant Grit, which locally reaches a height of 1,371 feet. Reference is made to the 'plastic clay' in the Millstone Grit, a fine mealy sand due to the decomposition of chert, which was formed from very fine siliceous sediment, partly of clastic quartz grains and partly of organic material. Full particulars relating to the Coal-measures are given by Dr. Strahan. The lower seams of coal, traced along the 'North Crop,' from the Tawe valley through Ammanford and the Llandybie district to the Gwendraeth valley, are all anthracitic; whereas in the 'South Crop' the lower seams "are all bituminous, and there is little doubt that in the intervening ground they pass through the intermediate stage of steam-coal."

In the Swansea area the Coal-measures attain a greater thickness than is at present known in any other part of the coalfield, about 7,000 feet. In this great series is included about 1,050 feet of the highest measures. Seams are worked in all three divisions of the series.

A notable discovery by Logan was that of pebbles of coal in the Pennant Grit near Swansea. We fail to find any particular reference to this, although incidentally the occurrence of pebbles of coal is mentioned.

In the Swansea map are included the eastern portions of the picturesque region of Gower, where Silurian rocks were discovered by Mr. Tiddeman. There are many other features of great interest in that promontory, in the lithological characters of the Lower Carboniferous rocks, and in the disturbances to which they have been subjected. The dolomitisation of the limestone, to which special attention has been given by Dr. Pollard and Mr. Dixon, is regarded as for the most part contemporaneous, the alteration having taken place so shortly after deposition that the magnesian salts were probably derived from the Carboniferous sea. Again, the recognition of radiolarian cherts in the Upper Limestone Shales confirms De la Beche's correlation of the strata with the Coddon Hill Beds of North Devon.

The Glacial Drifts in the areas of Ammanford and Swansea indicate the former great development of ice in regions further north, whence there was a southerly movement, the ice overriding and glaciating all except the higher hills. Important, too, is the evidence gathered by Mr. Tiddeman that this glaciation is later than the Raised Beach of Gower and the Cave accumulations with Pleistocene mammalia.

II.—The Geology of the Leicestershire and South Derbyshire Coalfield. By C. Fox-Strangways, F.G.S.; with Palæontological Notes and List of Fossils by A. R. Horwood. 8vo; pp. 373, with colour-printed geological map, 6 plates, and 12 text-figures. Cloth; price 6*s*.

IN 1860 a concise memoir by Edward Hull on "The Geology of the Leicestershire Coalfield and of the Country around Ashby-de-la-Zouch" was issued by the Geological Survey. It occupied 70 pages of print, was accompanied by a neatly coloured geological map engraved by Lowry, and was sold at the price of 3*s*. It was a handy memoir, well adapted for the pocket of anyone who was making a personal study of the area. Now after a lapse of nearly fifty years the results of a far more detailed survey, carried out on the six-inch scale entirely by Mr. Fox-Strangways, have been published in the memoir before us. Although the paper and printing of the present work do not equal that of the former one (see, for instance, the figure of Outcrop of the four-foot coal at Blackfordby), yet when we compare the bulk of this work with its predecessor—the number of printed pages, including much tabular matter, the large folding plates of sections, and the cloth case—a comparison of the respective prices is wholly in favour of the new volume.

It is pleasant to read that a cordial acknowledgment of the services rendered by the Rev. W. H. Coleman (given in the earlier volume) is also made in the present work, in which, indeed, there is a full bibliography drawn up with characteristic precision by Mr. Fox-Strangways. Everywhere throughout this volume we find a careful and methodical statement of the facts, with due acknowledgment of previous workers.

The author gives an interesting history of the development of the coalfield, from the earliest mention of coal-working in the district—the reign of King John in 1204—to the present-day workings. Mention is also made of the clay that has been extensively used in the manufacture of sanitary earthenware. Not the least important part from a practical point of view is the record of colliery borings and pit sections, which occupies nearly 200 pages. A useful chapter is also devoted to a consideration of the probable extension of the coalfield beyond the present workings. While, however, the memoir is mainly occupied with a detailed description of the Coal-measures, there are appropriate accounts of the older and newer formations, of the Pre-Cambrian, Triassic, Pleistocene, and Recent deposits.

Palæontological information is by no means neglected. There is a list of fossils from the Carboniferous Limestone based largely on a collection made by Mr. H. Vassall; while an important section on the palæontology of the Coal-measures has been contributed by Mr. A. R. Horwood, a zealous worker at Leicester.

In this full and practical account of the geology of an important coalfield are embodied the results of the final official field-work of the author, who has since retired from the public service.

III.—The Geology of the Lands End District. By Clement Reid, F.R.S., and J. S. Flett, M.A., D.Sc.; with contributions by B. S. N. Wilkinson, E. E. L. Dixon, B.Sc., and W. Pollard, M.A., D.Sc. Mining appendix by D. A. MacAlister, A.R.S.M. pp. 158, with 6 plates and 35 text-illustrations. Price 3*s*. 6*d*.

ATTENTION was drawn in the April number of the Geological Magazine to the memoir on "The Geology of Falmouth and Truro and of the Mining District of Camborne and Redruth." We are now able to introduce to notice the description of the adjacent area on the west, which includes the mining regions of St. Just, St. Ives, and Gwinear. The slaty rocks of this area are grouped as Lower Palæozoic, in accordance with Mr. J. B. Hill's grouping of the Mylor, Falmouth, and Portscatho Series, which may be Ordovician or of earlier date. More interest attaches to the physical structure of the district, to the greenstone and granite intrusions, to the effects of metamorphism, and to the genesis of the mineral veins. The sills of greenstone produce great alteration, which, however, extends but a short distance, in the adjoining killas; and rocks thus changed appear to have been little influenced by the subsequent granite intrusion. The granite is described as occurring in great sheets or laccolites, and to form an undulating floor over the whole of the region described, and at no great depth (as mentioned on p. 3), or at

depths of 4,000 to 5,000 feet (as noted on p. 8). This floor rises in domes and bosses, and its proximity to the surface is indicated by inliers of altered killas or of the metamorphic aureole. The coarse and the somewhat later fine-grained granite are duly described; and the effects of fluoric and boric vapours that emanated from the granite prior to its complete cooling and consolidation are pointed out. The 'schorl rock' and the variety known as luxullianite have been produced by these pneumatolytic processes; while most of the mineral lodes which occur in the metamorphic aureole surrounding the granite are attributed to like agencies. In the luminous chapters on these subjects, written conjointly by Mr. Reid and Dr. Flett, there is much that advances one's knowledge of these interesting phenomena.

An account is given of the possible preservation of Eocene gravel under the sea not far from St. Michael's Mount, and attention is directed to the phonolite of the Wolf Rock which is depicted in an inset on the colour-printed map, while its actual position is indicated in a small map on page 2. This volcanic rock may be of Tertiary age, but we are at a loss to understand why "no special description of the phonolite of the Wolf Rock is needed here." Being regarded as belonging to the district a description would have been just as appropriate as that of the granites and greenstones. We find also a somewhat meagre account of the very interesting Pliocene strata of St. Erth. Surely a list of the commoner fossils should have been given to accompany the instructive description of the physical conditions under which the deposits were accumulated.

The Appendix on Mining by Mr. MacAlister contains a full and well-illustrated account of the many mines and of the more important lodes, with much statistical information.

An excellent colour-printed map accompanies this memoir. It is compounded of Sheets 351 and 358, and the price is 2*s*. 6*d*.

IV.—A Guide to the Fossil Invertebrate Animals in the Department of Geology and Palæontology in the British Museum (Natural History), Cromwell Road, London, S.W. 8vo; pp. 182, with 7 plates and 96 text-figures. London: printed by order of the Trustees. Price 1*s*.

CONGRATULATIONS to Dr. Arthur Smith Woodward, F.R.S., the Keeper of Geology, on the issue of an entirely new guide to the Fossil Invertebrata, which we learn from the preface by Sir E. Ray Lankester, the Director, has been written by Dr. Francis A. Bather, the Assistant Keeper, with the help of Mr. R. Bullen Newton, Mr. G. C. Crick, in the Mollusca; Mr. W. D. Lang, in the Bryozoa and Corals; Dr. W. T. Calman, in the Arthropoda. Thanks are also given to Mr. S. S. Buckman, Mr. H. W. Burrows, Mr. C. Davies Sherborn, and Mr. B. B. Woodward.

Commencing with the stratigraphical series in Gallery XI. occupying the wall-cases on the west side we find a collection of the various kinds of rocks found in Britain, arranged in the order of their age by the late Mr. R. Etheridge, F.R.S. Along the top of the case is a diagram showing the succession of these rocks from the newest to

the oldest, as they might be seen in a continuous section across the country if one walked in a more or less straight line from east to west. Examples of the rocks themselves are placed on the shelves below, accompanied by numerous small sections of the strata as seen by observers in various parts of England. Affixed to the wall-cases is a series of small maps of Britain, each coloured to show the tract of country where the particular rock-group is exposed at or near to the surface, of which specimens are exhibited in the adjoining case. In the long section, at the top of the case, the number placed beneath each bed gives its approximate thickness in feet.

In connection with the subject of British strata reference is made to the important work done by William Smith, surnamed the "Father of English Geology," who was the first in this country to demonstrate the now fully recognised fact that each group of strata is marked by certain fossils. Therefore, when once a geologist knows the fossils characteristic of the various strata he can, if set down in any part of the country, readily determine on which bed in the geological series he is standing, if only he can find a few fossils to aid him. They are, in fact, the unerring 'spoor' to the geological hunter to guide him to his 'quarry.' A very good portrait of Smith is given in the Guide. This gallery is a veritable monument to William Smith; on the south wall is a copy of the original map geologically coloured by himself, and still in many respects a reliable guide. In the centre of the east wall is his bust (surrounded by maps and sections prepared by him) and surmounting a glazed case and cabinet containing his original collection, a monument to his genius as an original investigator and to his unwearying labour as a worker. In this gallery are also shown the collections of Mr. Searles V. Wood from the Crag, Mr. Edwards' from the Eocene, Mr. Sowerby's types of the Mineral Conchology, Dr. Davidson's Brachiopoda, Gilbertson's Carboniferous fossils, Brander's Eocene shells of Hampshire, Mr. König's types, and the few identifiable fossils of Sir Hans Sloane's Museum, the nucleus of the original British Museum (1753).

Nor do these important 'type' and stratigraphical collections exhaust this gallery, for at the further end, in wall-cases 6 and 7 and on the walls and opposite side, are brought together a very interesting series of specimens illustrating the work of dynamical, chemical, and organic agents—some caused by earth movements on a large scale, such as may be observed in the squeezing and crumpling of great masses of strata often miles in extent and thickness, as seen in mountain chains such as the Alps, the Andes, and the Himalayas, illustrated by models prepared by Lord Avebury and recently presented by him; others showing minute movements producing small faults, folds, and cleavage planes in rocks of various ages. Of chemical and concretionary structures there are again very many and varied examples, illustrated by 'dendritic markings,' 'cone-in-cone' structures, and a very wonderful series from the Magnesian Limestone of Durham, chiefly collected by Mr. G. Abbott, F.G.S., offering the most curious mimetic representations of organic structures, such as Stromatopora, and Corals in great variety, as well as globular and botryoidal forms. Many concretions also have organic nuclei, such

as shells, leaves of plants, fishes, teeth, etc.; these are illustrated in great variety, as well as the castings of worms and curious tracks formed by annelides, and the footprints left by birds and reptiles.

Coming to remains of once living organisms in Gallery X, the Guide gives us figures of Foraminifera, Radiolarians, and Sponges, showing the siliceous or calcareous skeletons as they actually occur in the rocks. Many of these minute organisms, as well as the more massive growths of coral reefs, helped in the older seas of the world's past to build up organic rocks, furnishing strata of vast extent and great thickness, such, for instance, as the Nummulitic Limestone, which contributes largely to the Pyrenees, the Alps, the Atlas Range, the Himalayas, etc. In this gallery, and well illustrated in the Guidebook, are the Corals, the Stromatoporoids, and the Graptolites, whilst the centre and the eastern side are occupied by the fossil plants, including many silicified tree-trunks from Tertiary and Jurassic rocks, and a fine case of Cycadean stems, some cut and polished. The coal-plants, too, form a large and attractive series.

Gallery IX, although closed to the general public, is open to students and scientific workers, and contains the library and special study collections.

No. VIII contains the beautiful series of stone lilies, mostly from the Secondary, Carboniferous, and Silurian rocks. Many excellent figures are given in the Guide. After the stone lilies we come to the Starfishes and Sea Urchins in endless variety. To these succeed the Trilobites and other Crustacea, the giant *Pterygotus*, and the king crabs and scorpions, with many kinds of dragon flies and other insects from the Coal-measures upwards; and next these the Bryozoa and Brachiopoda. The west side of this large gallery is entirely given up to the display of the Gasteropoda and Lamellibranchiata, which, commencing with the glacial shells and those from raised beaches and the shells from the Peat and Lake deposits, go back in time to the earliest Silurian and Cambrian rocks.

The Mollusca, ancient and modern, form such a vast series that the higher forms, the Cephalopoda, Cuttle-fish, Nautili, Ammonites, and Orthoceratа, require a whole gallery (No. VII) entirely to themselves. Probably in no other museum in the world can such a display of the chambered shelled Cephalopods be seen as is exhibited in this gallery, of which the Keeper of the Geological Department, Dr. A. Smith Woodward, may be justly proud. The largest coiled British Ammonite is a *Pachydiscus leptophyllus*, 3 ft. 8 in. in diameter, from the Chalk of Rottingdean, near Brighton. But this is far surpassed by *P. Seppenradensis*, an Ammonite from the Chalk of Westphalia, a cast of the shell of which, having a diameter of 6 ft. 8 in., is fixed on the north wall.

But we must end this notice by commending the lover of natural history to purchase a copy of this very admirable Guide, which is really a textbook for one shilling, beautifully illustrated with 7 plates and 96 text-figures admirably executed, forming a most attractive handbook for the student and the casual visitor alike. We compliment the Keeper of Geology and his Assistant Keeper, Dr. F. A. Bather, the writer, and his colleagues, who together have produced so splendid a shilling's worth.

V.—Memoirs of the Geological Survey of Great Britain.

Memoir of the Geological Structure of the North-West Highlands of Scotland. By B. N. Peach, LL.D., F.R.S., John Horne, LL.D., F.R.S., the late W. Gunn, C. T. Clough, M.A., F.G.S., and L. W. Hinxman, B.A.; with Petrological Chapters and Notes by J. J. H. Teall, M.A., D.Sc., F.R.S. Edited by Sir Archibald Geikie, K.C.B., D.C.L., Sec. R.S. Edinburgh, W. & A. K. Johnston, Ltd.; Glasgow, Jas. Hedderwick & Sons, Ltd. 8vo; pp. xviii and 670, with 52 plates and a geological map of the North-West Highlands of Scotland, and 66 figures in text. Price 10*s.* 6*d.* (Preliminary notice.)

THIS memoir, on the geological structure of the North-West Highlands of Scotland, is one of the most important which has been issued by the Geological Survey, as it relates to a region which has become classic for the study of the more powerful movements whereby the earth's crust has been affected.

The opening chapter gives a brief account of the various rock-groups to be found in that region, their geological relations, and the remarkable structures which they present in the field. It is followed by a historical account of the development of the research, special reference being made to the controversy between Sir R. I. Murchison and Prof. Nicol regarding the structure of the North-West Highlands, and to the investigations which led to a settlement of the dispute.

A detailed account is given of the structure, distribution, and petrography of the Lewisian Gneiss and Torridon Sandstone along the western portions of the counties of Sutherland and Ross. The various subdivisions of the Cambrian formation are enumerated, and, for the first time, a description is furnished of the distribution and organic contents of the *Olenellus* zone, which has been detected and traced by the Geological Survey for 100 miles.

But the feature which renders the volume of exceptional interest to geologists all over the world is the description and illustration of those great displacements of the earth's crust, whereby slices of the older rocks have been driven westwards for miles and made to rest on younger strata. The detailed evidence in proof of such movements is set forth in part iv.

The concluding section of the work (part v) gives a brief account of the petrography, distribution, and geological relations of the Eastern Schists, which lie above the most easterly of the great planes of disruption in that region. The age of those crystalline schists is still unsolved.

The volume is illustrated by 52 plates, 66 text-figures, and a colour-printed geological map of the area between the north coast of Sutherland and Sleat in Skye on the scale of four miles to one inch.

Copies may be obtained from any agents for the sale of Ordnance Survey maps, or through Messrs. Dulau & Co., 37, Soho Square, W., from the Ordnance Survey Office, Southampton. Price 10*s.* 6*d.* (postage 10*d.* additional).

A full review of this important work will appear in next month's Geological Magazine.

REPORTS AND PROCEEDINGS.

Centenary of the Geological Society of London.

The Centenary Celebration of the Geological Society of London, to which we drew the attention of our readers in the Geological Magazine for January last, pp. 1–3, and again in our September number, pp. 385–389, has come and gone. The numerous foreign and Colonial visitors have been hospitably entertained; geological excursions and visits to our Museums and Universities had previously been arranged for their honour and gratification. The President, Secretaries, Treasurer, and Council have all exerted themselves to render the stay of such distinguished guests as agreeable as possible, and it is to be hoped they will carry away with them pleasant memories of their English visit.

On Thursday, the 26th September, a reception was held at the Institution of Civil Engineers at 11 o'clock, when the delegates from Foreign and British Scientific Societies and Academies offered congratulatory addresses to the President, Sir Archibald Geikie, K.C.B., and he personally was presented with the Gold Medal of the Institution of Mining and Metallurgy, which was handed to him by C. J. Alford, Esq., F.G.S., on behalf of that body.

At 3 o'clock the President read his address on "The State of Geology at the Time of the Foundation of the Geological Society, in 1807." He gave a sketch of our science a hundred years ago, and described the work of its first President, George Bellas Greenough, and its other founders. He referred to the labours of William Smith, known as "Strata Smith," and named by Sedgwick "the Father of English Geology." He pictured the state of knowledge regarding the structure and history of the earth as it was at the beginning of the last century, and of the conflict of opinions at the time which raged between the followers of Werner and Hutton, the Neptunists and the Plutonists. He showed how much the miner and mineralogist had to do with the origin of the science and the great advance of geological knowledge at the present time.

A banquet was held in the evening at the Whitehall Rooms of the Hôtel Métropole, at which 291 were present. After the President had proposed the toast of the King and the heads of Foreign Countries, Professor A. de Lapparent proposed that of the Geological Society, which was followed by speeches from Professor Lapworth and other distinguished Fellows and delegates.

The Universities of Oxford and Cambridge on the 30th September and 1st October conferred respectively degrees as follows:—Oxford, D.Sc. *honoris causâ*, Professor Charles Barrois, Professor Albert Heim, Professor Alfred Lacroix, Dr. Hans H. Reusch, Professor Albrecht Penck, and Professor Geheimrath Ferdinand Zirkel. Cambridge, Sc.D. *honoris causâ*: Professor W. C. Brögger, Professor Hermann Credner, Professor L. Dollo, Professor A. de Lapparent, and Professor A. G.

Nathorst. Professor Geheimrath H. Rosenbusch could not be present to receive his degree.

Over 470 cards of identification were issued by the Society to Fellows, delegates, and guests attending the Centenary. Sixteen Foreign Members and 14 Foreign Correspondents, besides many other foreign and Colonial visitors, were present. The following were the countries represented: Austria-Hungary, Argentine Confederation, Belgium, Denmark, Egypt, France, German Empire, Greece, Holland, Italy, Japan, Mexico, Norway, Portugal, Russia, Sweden, Switzerland, United States, also the Dominion of Canada, India, South Africa, the Commonwealth of Australia, and the Dominion of New Zealand.

CORRESPONDENCE.

NOMENCLATURE OF AUSTRALIAN SILURIAN OPHIURIDS.

Sir,—Presumably this heading to Mr. Chapman's welcome letter (Geol. Mag., Oct. 1907, p. 479) does not imply that Silurian Ophiurids are to be excepted from the laws of nomenclature when they occur at the Antipodes. Yet the difference between us could scarcely have arisen had Mr. Chapman felt himself bound by certain rules adopted at all recent sessions of the International Congress of Zoologists. But he is not even loyal to the Stricklandian code, preferring rather to follow 'an unwritten rule.' Perusal of the modern code, of which I believe Mr. Chapman has now received a copy, will, I hope, show him that my remarks concerning *Sturtzura* were in simple accordance with elementary rules. It is not my business to defend those rules, but since Mr. Chapman assumes that his own views are shared by others, I ask leave to put the real point in dispute as clearly as I can.

The object of selecting a type—whether type-specimen (holotype) of a species, or type-species (genotype) of a genus—is, not to indicate to one's readers what one believes to be the most characteristic form (norm) of the species or genus under discussion, but to fix on a form according to which the species or genus shall stand or fall. Experience has taught us that we all make mistakes in our descriptions, and that the most carefully constructed diagnosis may prove erroneous. A nomenclature based on diagnoses and on various rational or ethical principles has been tried and found wanting. Therefore zoologists have said: "We will exclude all these sources of human error from the foundations of our nomenclature so far as is possible, and we will base our work on concrete specimens."

Professor Gregory fixed on *Protaster brisingoides* as the genotype of *Sturtzura*. His interpretation may have been right or wrong, but this at any rate is sure: what *P. brisingoides* is, the same is *Sturtzura*; whatever the diagnosis may be, all species congeneric with *P. brisingoides* are also *Sturtzura*, unless they include the genotype of a prior genus. For example, if *P. brisingoides* be congeneric with *P. sedgwicki*, *Sturtzura* yields to the prior *Protaster*; but if it be

congeneric only with *P. leptosoma* as Gregory maintained, or only with *P. biforis* as I have hypothetically imagined, then the name *Sturtzura* stands. (Internat. Rules, 1905, Art. 29.)

That the rule referred to in the phrase "once a synonym, always a synonym" has no bearing on either of these suppositions, is evident when its meaning is understood. The rule, in fact, simply states that a generic name once used in zoological nomenclature cannot be used for any subsequent genus that does not include the original genotype, even when the name as first used has proved to be a synonym. But if the rule does not forbid the resuscitation of *Sturtzura* for a genus containing the genotype *S. brisingoides*, it certainly does forbid its use for a genus comprising only *S. leptosoma* and *S. leptosomoides*. (Internat. Rules, 1905, Art. 36.)

Mr. Chapman may not approve of these rules, and I do not pretend that I like them all myself. But in these matters of form it is surely better that individuals should come into line with the great majority of their colleagues.

My protest against the composition of certain names was not made from the standpoint of a museum curator, as Mr. Chapman seems to suppose, but from that of the compilers of the Stricklandian code, who desired to render "our scientific language palatable to the scholar and the man of taste." If a name is held to have no meaning, let it at least be euphonious; but if it is intended to have a meaning, that need not be a ridiculous one.

As for the more important matter—the homologies of the arm-ossicles, there seems no grave objection to the compromise now proposed by Mr. Chapman. But whether the ambulacrals consist of one piece as I suggested, or of two pieces as he now suggests, will probably not be decided until we find specimens with the stereom undissolved.

F. A. Bather.

London, 7 *October*, 1907.

COLLODION AS A PRESERVATIVE FOR FOSSILS.

Sir,—Dr. Bather's interesting article on collodion imprints reminds me of an intention I have long had of communicating to you another use for collodion. The usual method of preserving fragile fossils by application of a hot gelatine solution is one which I have always found troublesome and unsatisfactory. Some years ago a student suggested to me that a solution of collodion would penetrate more readily, could be used at ordinary temperatures, and would become solid more slowly. He gave me some solution that he was using for some other purpose—a saturated solution of gun-cotton in equal parts of amyl acetate and ethyl alcohol. I found this answer very well, both for preventing the flaking of delicate fossils and for mending broken ones. Small specimens can be simply immersed in the solution, left there (in a corked tube) for an indefinite period, and finally lifted out and dried. Larger ones may be painted over, several times if necessary. I have by this means mended, among other things, broken specimens from Wenlock Limestone and Chalk Marl,

and even large Jurassic oysters, though in the last case they are apt to break again on ordinary handling. I have been too lazy to experiment with variations on the original recipe given me, but from conversations with several chemists I gather that a simple solution of collodion in amyl acetate would probably act as well as the one I have been using.

A. Morley Davies.

Underwood, Winchmore Hill, Amersham.
21*st October*, 1907.

SALINE SOLUTIONS AND ORES.

Sir,—The Geological Magazine has afforded me the opportunity to champion many unpopular causes scouted elsewhere. Perhaps the greatest offender has been the significance of chlorides in granitic quartzes. The ubiquity of chlorides throughout the Dartmoor mass, and, so far as I am aware, in the Cornish elvans also, impressed me greatly. There must be some reason for it. I endeavoured to account for their origin, but could see no practical importance in what seemed to be a purely petrological puzzle.

I now see that Mr. E. C. Sullivan, in discussing the interaction between minerals and water-solutions, points out that "salt solutions, as decomposing agents, are much more active than pure water, and are comparable with acids in this respect." Mr. H. Foster Bain also points out, with reference to zinc and lead, that "the ore bodies are doubtless due to concentration or re-concentration through the action of underground waters" (*Nature*, vol. lxxvi, p. 559). Here we have a direct connection indicated between the Devon and Cornish mineral veins and the ubiquitous chlorides of potassium or sodium; also a possible explanation of the common connection between chlorides and the schorl rocks of the Western counties.

If I can get metallurgists and chemists to perceive that chlorides in quartzes may have a distinct bearing on practical mining, and above all money-making, the investigation of the chloride problem will be secured, and there will be no need for me to further trouble my many geological friends by my importunity.

When a most distinguished authority said that I based my world on an elephant, the elephant on a tortoise, and the tortoise on microscopic grains of chloride of sodium, he stated the absolute truth. The chlorides, both as to their origin and their significance, have puzzled me more than any other petrological conundrum.

I am fully convinced that petrologists have no idea how ubiquitous the chlorides are in the Western granites. One amateur friend assures me they are very rare. An expert friend, to whose diagnosis I submit unreservedly, once sent me a slide for me to say whether there were *any* chlorides in it. The slide was mounted with an asphaltum ring, precluding the use of a high-powered objective, and the cover was not too thin. It abounded in chlorides—in fact, was rather a good example. It once took me about three evenings' work with the $\frac{1}{6}$ to conquer one refractory slide, but at last I detected one very minute cube. That of course sufficed to prove the presence of chlorides when the quartzes crystallised. Of course, my point is the diffusion of

chlorides throughout the district, not the optical abundance of cubes in every slide. Moreover, brine solutions cannot be detected unless sufficiently concentrated to deposit crystals. It is quite likely that in the slide referred to all the fluid inclusions are saline, even though only one of them can be proved by the microscope.

A. R. Hunt.

Foxworthy, Moretonhampstead.
2nd October, 1907.

OBITUARY.

PROFESSOR CHARLES STEWART, LL.D., M.R.C.S., F.R.S., F.L.S., F.R.M.S.

Born 1840. Died September 27, 1907.

By the death of Professor Charles Stewart, which has occurred after a somewhat protracted illness, the Royal College of Surgeons of England has lost one who has successfully filled the office of conservator of the museum for the past twenty-three years. After attending as a medical student at St. Bartholomew's Hospital Professor Stewart became a member of the Royal College of Surgeons in the year 1862. He was admitted a Fellow of the Linnæan Society in 1866, and was President of that body during the years 1890 to 1894, and in the following year served as Vice-President. Professor Stewart was also a Fellow and Vice-President of the Royal Microscopical Society, and became one of its honorary secretaries in 1878. He was Treasurer of the Anatomical Society of Great Britain and Ireland from its foundation until 1891. During the period 1894–1897 he held the office of Fullerian Professor of Physiology at the Royal Institution, and delivered several evening lectures at the same place. He was admitted a Fellow of the Royal Society in 1896, and obtained the honorary LL.D. of Aberdeen University. Before being appointed Conservator of the College of Surgeons' Museum Professor Stewart was curator of the museum of St. Thomas's Hospital, lecturer on Comparative Anatomy, and joint lecturer with Professor John Harley on Physiology at that institution. He was subsequently appointed Professor of Biology and Physiology at Bedford College. In the year following his appointment at the College of Surgeons he was elected Hunterian Professor of Human and Comparative Anatomy, and held the post until the year 1894. The true value of Professor Stewart's scientific work is not to be judged solely by his writings, which, in spite of the vast extent of his knowledge gained from his personal observations, were comparatively few in number, but it is to be seen rather on the shelves of the College Museum in the unrivalled series of preparations and dissections by which he sought, in continuation of the work of previous Conservators, to illustrate important phases in the evolution of the organic world and thus to amplify the original scheme of John Hunter, whose collection forms the nucleus of the College museum. Professor

Stewart was a master in the art of lecturing. His easy and lucid style, combined with a rare power of swift and effective drawing on the blackboard, would have made his addresses notable quite apart from the peculiar charm of his delivery.—*The Morning Post*, Saturday, September 28th, 1907.

EDMUND MOJSISOVICS VON MOJSVAR, Sc.D.

We regret to record the death at Mallnitz, on the 2nd October, of the eminent Austro-Hungarian geologist and palæontologist, Johann August Georg Edmund Mojsisovics, Edler von Mojsvár, Sc.D. Camb., Foreign Memb. Geol. Soc. Lond., author of numerous memoirs on the Cephalopoda of the Austrian Trias, to the description and illustration of which he devoted very many years of his life. He was a member of the k.k. Geologischen Reichsanstalt in Vienna; and usually resided at Strohgasse, 26, Vienna 3/3. We hope to give a fuller notice of Dr. E. Mojsisovics later on.

REV. RICHARD BARON, F.L.S., F.G.S.

Born 1847. Died October 12, 1907.

We regret to record the death (from heart-failure, following an attack of malarial fever) of the Rev. Richard Baron, who for thirty-five years was engaged in missionary work at Antananarivo, Madagascar, in connection with the London Missionary Society. Mr. Baron was a frequent contributor to the *Antananarivo Annual*, and took an earnest interest in the botany, geology, and palæontology of Madagascar. In March, 1889, he communicated to the Geological Society of London, through the Director-General of the Geological Survey, some interesting notes on the geology of Madagascar, with an appendix on some fossils collected by him, by Mr. R. Bullen Newton, F.G.S., of the British Museum (Natural History). At the same meeting, March 6th, 1889, Dr. F. H. Hatch, F.G.S., contributed some notes on the petrographical characters of some rocks collected by Mr. Baron (Geol. Mag., 1889, pp. 234–235, and Quart. Journ. Geol. Soc., 1889, vol. xiv, pp. 305–331, pl. xiii, and map). A second extensive collection of Invertebrate fossils was made by Mr. Baron in 1891, during a journey of 1,200 miles, in which he visited the east coast, the northern end of Madagascar, and the north-west coast and adjacent islands. His description of the geology and the rocks examined form the subject of an excellent paper read before the Geological Society, November 21st, 1894 (Quart. Journ. Geol. Soc., vol. li, 1895, pp. 57–71, pl. i), to which Mr. R. B. Newton contributed a description of the fossils obtained by Mr. Baron (op. cit., pp. 72–92, pls. ii and iii).

From Mr. Baron's observations and collections we learn that sedimentary rocks occur mainly on the western and southern sides of the island. From the fossils brought home it appears that the following formations are represented, namely: Eocene, Upper Cretaceous, Neocomian, Oxfordian, Lower Oolitic, and Liassic rocks.

Possibly some of the slaty beds may prove to be of Silurian or Cambrian age. Recent deposits fringe the coast and are largely developed on the southern part of the island. The alluvial and peat deposits and old lake-bed accumulations have been largely explored by Dr. C. I. Forsyth Major and later by Mr. Standing, and have yielded numerous genera of *Nesopithecus*, *Megaladapis*, *Hippopotamus*, Crocodilia, Chelonia, *Aepyornis*, etc. Mr. Baron also discovered the fossil remains of one of those long-snouted Gavial-like Crocodilia, considered to be of Lower Oolitic age, which was described and figured by Mr. R. B. Newton in the Geol. Mag., 1893, pp. 193–198, Pl. IX, under the name of *Steneosaurus Baroni*.

It is interesting to mention that in the rocks described in 1889 by the Rev. Richard Baron as Jurassic in North-West Madagascar, the remains of a Sauropodous Dinosaur, referred by Mr. R. Lydekker to *Bothriospondylus Madagascariensis*, should have been obtained by Mr. J. L. Last, closely resembling forms found near Oxford, also at Fletton, near Peterborough, and in the Kimeridge Clay of Wiltshire (see Quart. Journ. Geol. Soc., 1895, vol. li, pp. 329–336).

Mr. Baron furthermore communicated to the Linnean Society a valuable paper on "The Flora of Madagascar" (Journ. Linn. Soc. Bot., vol. xxv, 1888, pp. 246–350), and was the author of the first geological textbook in Malagasy, 1896, pp. 191, with numerous illustrations in the text, a copy of which is preserved in the Geological Department of the British Museum.

In 1891 the Council of the Geological Society of London marked their appreciation of Mr. Baron's geological work in Madagascar by the award of the balance of the proceeds of the Murchison Geological Fund, in testimony of the interest taken by them in the geological work which amid many discouragements he was carrying on in Madagascar.

Geologists owe a great debt of gratitude to such men as the Rev. Richard Baron and Mr. Standing in Madagascar, and the Rev. Samuel Couling, M.A., at Ching-chou-fu, Kiao-chow, North China, who in such distant regions and amid inimical surroundings have, with but little encouragement, carried on most valuable scientific researches and stimulated others to follow where they have led the way.

MISCELLANEOUS.

Serviço Geologico e Mineralogico do Brazil.—By a decree approved January 10th, 1907, the Federal Government of Brazil has established a Geological Survey with the title of Serviço Geologico e Mineralogico do Brazil, as a bureau of the Department of Industry, Highways, and Public Works. The service has already been organized, and systematic work has been commenced. The results of the Survey's work will be published as rapidly as possible. Communications and exchanges should be addressed to the office of the service at No. 49, Rua da Quitanda, Rio de Janeiro, Brazil. Orville A. Derby, Chief.